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AN EXPLORATORY STUDY OF
THE USE OF PARAMETRIC ESTIMATING IN
DEPARTMENT OF DEFENSE CONTRACTING

THESIS

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THESIS

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Abstract

An initiative to expand the use of parametric estimating in government contracting has enjoyed only marginal success. Some reasons for the slower pace of implementation are the lack of availability of historical data, training, acquisition rules, utility, and accuracy concerns. Those associated with the Parametric Cost Estimating Initiative (PCEI) have a higher perception of parametric utility and accuracy than those not associated with the initiative. The PCEI advocates using parametric techniques in any situation, not just the concept/development phases advocated by most literature.

Parametric estimating is a catch-all term for several different types of statistically based methodologies, ranging from simple CERs to complex models. Each type has different implementation requirements. Using the single term parametrics can be very deceiving, making it difficult for management to allocate resources necessary for implemetation.

PCEI and non-PCEI acquisition groups have similar perceptions of accuracy and utility for CERs, but different perceptions for more complex parametric models. The PCEI has been successful expanding the use of parametrics, though not significantly enough to be persuasive. Most of the PCEI successes have been related to CERs, not complex models. Advances in complex model use has occurred with contractors who routinely develop state of the art hardware.

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I. Introduction

We are in the midst of change. Certainly the nature of acquisition has changed,

affected by smaller budgets, smaller forces, and a focus on efficiency in all aspects of

commercial and government business operations. Every phase of the Government's

acquisition process is being reviewed and reengineered to improve its efficiency

(Statutory/Policy Changes, 1998:1). In the past, the acquisition of new weapon systems

was characterized by actual costs ultimately being greater than their original estimated

costs. The 1990's has seen acquisition reform and affordability emphasized as primary

goals within the Department of Defense (DoD), with commercial practices being

encouraged and non-value added tasks being discouraged (Widmann and others,

1997:433).

One area of acquisition reform being examined is improvement of cost estimating

tools and processes. The emphasis on downsizing and budget cuts will no longer support

ineffective cost estimating. Our study investigates whether current acquisition cost

estimating policies add value and are perceived to be effective in predicting future DoD

weapon system cost. Current estimating practices are considered inefficient because the

processes are labor intensive, cycle times are long, and the tools and processes have not always provided the best and most timely results (Spector, 1995:1). The environment requires the cost estimating community consider different tools and processes which may provide more credible estimates and, at the same, time reduce the substantial labor involvement. The time is ripe for the introduction of new computer-driven techniques if those techniques can provide accuracy and time savings. The need to be more efficient and reduce costs in the DoD has led to the Parametric Cost Estimating Initiative (PCEI).

Cost Estimating Methodologies

Cost estimating has played a fundamental role in the acquisition process (Zhang and others, 1996:95; McDonald, 1992:D.3.1; Smith and Mason, 1997:137). It provides information to make trade-off decisions between alternative solutions and establishes the standards of acceptability against which the effectiveness of the solutions are measured (Zhang and others, 1996:95; Doraiswamy and Hunt, 1994:Q.M.4.4). Cost estimating is essentially a computational process used to predict the future cost of a system or product. Very rarely are all the parameters or conditions known when the estimate is prepared.

There are three basic estimating methodologies: cost build-up or bottoms-up, analogy, and parametrics (Widmann and others, 1997:434). A detailed discussion of the methodologies is provided in Chapter II. In general, the methods differ based on the information available, the nature of the project or program, and the time available to prepare the estimate (De la Garza and Rouohana, 1995:14). The cost build-up method uses the most currently available information or expert judgment obtained from managers

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responsible for performing the task and derives a total cost by summation of the various tasks and cost elements (Widmann and others, 1997:434). The analogy method typically finds historical data for previously built similar items or tasks, and applies a subjective adjustment factor based on the degree of increased or decreased difficulty of producing the particular item or performing the particular task. The cost build-up and analogy methods of estimating are commonly used in contracting and are generally well understood. However, obtaining the information to prepare these types of cost estimates is often difficult and time consuming, especially early in an acquisition cycle. The third basic method is parametrics. Parametric applications imply the use of estimating relationships or models to predict elements of cost or total cost.

Parametric Estimating Applications

Once it has been determined to use parametric estimating, there are choices about which type of parametric application to use. Parametric estimating is an encompassing term which includes everything from a simple cost estimating relationship (CER) that estimates one element of cost, to complex proprietary commercial models that estimate the entire cost of a procurement. CERs are mathematical expressions that relate cost as the dependent variable to one or more independent cost-driving variables (DoD, 1995:35). There are two types of CERs - cost-to-cost and cost-to-non-cost. Estimating quality hours using manufacturing hours as a base is an example of a cost-to-cost CER. Development of overhead costs also involves the application of cost-to-cost CERs since it relates overhead costs to some direct base. Estimating technical publication costs using a

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dollar per page factor is an example of a cost-to-non-cost CER. Another example is the use of the dollars per pound CER to approximate airframe cost. When numerous CERs are used in combination to derive an estimate, the combination of CERs becomes a parametric model. Parametric models can be used to estimate a significant portion or the entire cost of a proposal (DoD, 1995:9).

Parametric applications vary significantly in how difficult they are to develop, use, explain, and how much they are currently used. Cost-to-cost CERs are very popular and simple to develop, use, and explain. Commercial models that develop entire proposal costs are very complex, require specialized training, and have been used sparingly in establishing firm contract prices.

Research Objective

Since the formation of the International Society of Parametric Analyst (ISPA) in 1978, there have been numerous efforts to promote the use of parametric estimating in commercial and government contracting. The belief has long existed that it takes too long to prepare, evaluate, and negotiate estimates, and that parametrics can achieve the same level of accuracy more efficiently. The PCEI provides the current push to expand the use of parametric estimating into the contracting process.

The PCEI is attempting to expand the use of parametric methods over other basic estimating methods in situations where it has not been the preferred method. This expanded use of the parametric method involves all types of parametric applications. The objective of this research is to provide a comparison between the established

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understanding of parametric uses, and compare that baseline understanding to the positions advocated by the PCEI. In doing so, the research will evaluate some of the fundamental positions of the PCEI. To be successful, the PCEI needs to know what situations parametrics would be most useful and when used, which application would be most useful.

Another objective of this research is to examine why parametrics have not been more widely used in DoD firm contracting proposals. An important aspect of this is DoD customer perceptions of parametric estimating and how those perceptions compare to the baseline understanding of parametrics and the positions advocated by the PCEI.

The PCEI's plan expands the use of parametric estimating into the area of establishing firm contract prices. This has not happened in the past because the cost build-up and analogy approaches were believed to be most accurate. However, significant effort to expand the use of parametric estimating into DoD contracting continues because current processes are considered inefficient. It is also believed that parametric estimating is a better way of preparing an estimate, combining accuracy and efficiency. These and related assertions are causing the expenditure of extensive resources to expand the role of parametric estimating in the contracting arena. If parametric estimating is inappropriate for the purposes planned, then the resources currently being devoted to implementing it are being wasted. The improper use of parametric estimating could lead to inaccurate estimates causing additional wasted resources, improperly funded programs, and associated acquisition perturbations. Without this investigation into perceived differences between cost estimating techniques,

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practitioners and researchers may be basing important decisions on inadequate information.

The current environment focuses on getting quicker and cheaper products and services but still emphasizes processes that make sense and produce the best results. Where can real efficiencies be achieved and top quality products obtained? To make a determination about the proper uses of parametric estimating, the principles and techniques germane to the field of cost estimating must be reviewed and understood.

II. Literature Review

Cost estimating is the process of forecasting a future result in terms of cost, based upon currently available information such as historical data or observations (ASPM, 1975:A1-B6; ASD, 1989:110). Estimates are derived for many purposes and during several stages of the acquisition process. Many considerations go into deriving these cost estimates. While the considerations to determine the appropriate method are intertwined, the overriding considerations are: purpose of the intended estimate; quality of the information available to develop the estimate; and the time and resource constraints devoted to developing the estimate. Examining the traditional intended purpose and use of parametric estimating requires a review and understanding of the general concept of cost estimation. To properly address this, we review the general field of cost estimation and how that general body of knowledge influences the use of parametric estimating. Following the cost estimation area will be a review of the Parametric Cost Estimating Initiative (PCEI). The establishment of the initiative will be discussed, along with the PCEI's goals and objectives. A chapter summary closes the chapter.

Cost Estimating: Establishing a Baseline for Parametric Estimating

This section of the literature review will provide a theoretical perspective of the types and purposes of estimating methods. In addition, it will provide a working definition of parametrics, examine accuracy and risk analysis, and present the potential usefulness or utility of parametric models as contained in the literature.

Estimating Methods, Definition and Purposes. The literature supports classifying cost estimating techniques by both the method employed to prepare a cost estimate and the intended purpose of the estimate. Both the method and purpose classification systems produce similar results. A discussion of the cost estimating methods will be considered first, followed by an amplification of the parametric method and its characteristics and definitions.

There are three primary methods of cost estimation techniques used to prepare estimates: 1) cost build-up or bottoms-up, 2) analogy, and 3) parametrics (Widmann and others, 1997:434). The cost build-up methodology is perceived as being more certain or accurate and the parametric methodology as being least certain. The cost build-up approach is more certain because it provides a total product cost based on a summation of individual task and cost elements. Normally used during the mature portions of the acquisition cycle, cost build-up produces fairly accurate estimates based on information about the detailed design of the product or system (Widmann and others, 1997:434). Actual or quoted cost information is available on material costs and processes. Labor costs, as a further example, can be accurately determined based on the expert judgment from the engineers or specialists who perform the task. The final cost is determined by summarizing the individual cost elements and applying overhead rates or other estimating relationships.

The analogy method is used when there is a sufficient degree of similarity between the product being developed and an existing product (Widmann and others, 1997:434). Historical data from the existing product is used to provide a basic cost value for the new

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product. An adjustment factor is then applied based on the degree of increased or decreased difficulty in producing the product or performing the task.

Both the cost build-up and analogy methods of estimating are commonly used in DoD contracting and are generally well understood. The third method, parametrics, is a paradox. Certain types of parametrics are simple and well understood, others complex.

Definitions and Categories of Parametric Estimating. The literature contains numerous and varied definitions for the broad term of parametric estimating. There are many types of parametric estimating techniques, some very simple, well understood and commonly used, and some very complex. An analysis of the various definitions contained in literature provides a means of categorizing the types of parametric estimating applications according to their use and complexity. As noted above, the scope of parametric estimating is very large and many applications of the technique are used for various purposes. Simple parametric applications, like estimating relationships at the cost element level, are used in creating portions of firm prices. Conceptual estimates use more complex parametric models which may develop all or part of the estimate.

Most of the literature characterizes parametrics in terms of mathematical relationships. Some theorists and practitioners treat it as a special branch of econometric analysis involving cost functions, micro constructs, model validation procedures, and forecasting using a full range of statistical tools (Parametric Cost Estimating Course Manual, 1987:4). Cost Estimating Relationships (CERs) are a common component in many definitions. To that end, parametrics has been described as an estimate that uses one or more CERs and associated mathematical algorithms or logic to establish cost

estimates (DoD, 1995:165). CERs are used to measure and estimate the cost associated with the development, manufacture, or modification of a specified end item, basing the measurement on technical, physical or other end item characteristics (DoD, 1995:198).

CERs can be based on either cost-to-cost or cost-to-non-cost type relationships. The difference between the two types of CERs is the base of the estimating relationship. If the base is a cost related parameter, the CER is cost-to-cost. An example is the commonly used approach to estimate overhead where the base is a cost item like manufacturing or material dollars. If the base of the CER is a physical attribute associated with the end item, the CER is cost-to-non-cost. Cost-to-non-cost CERs include hours per drawing or dollars per pound relationships. In other words, CERs are mathematical expressions which relate the dependent variable of cost to the independent variables (DoD, 1995:165).

More complex parametrics applications can be characterized in terms of the types of models used. These models may be simple cost estimating relationships or they may be quite complex involving linked relationships (Parametric Cost Estimating Course Manual, 1987:4). The term linkage implies that a change in an item's design affects the related cost of manufacturing and other support functions. A parametric model accounts for these related and cost impacts. A parametric model is a group of CERs used together to estimate the entire proposal or a significant portion of the proposal (DoD, 1995:9).

There are two main types of cost models: in-house and commercially available models. In-house models are end item contractor developed models. The historical data used to develop the model is almost exclusively from the end-item contractor's

accounting and management system. Commercially available models are developed by companies whose sole business is developing models to be used by virtually any contractor in any business or any product. The data used to develop these models is obtained from numerous contractors and programs over a long period of time. Commercial models have to be adapted to the end item contractor through a calibration and validation process. Calibration and validation are procedures for adjusting a commercial model to a specific contractor because of differences in his processes, efficiencies or any other contractor specific peculiarities (DoD, 1995:95). Both types of models can estimate portions of or the entire cost of a proposal.

From these definitions and characterizations, several key terms and concepts are presented. Parametrics include cost functions and forecasting cost estimates using statistical tools. Parametrics requires CERs based on cost, technical, physical, and other end item characteristics and models that will include CERs that will estimate portions of or the entire cost of a product. Many definitions incorporate the terms above in various combinations.

In summary, key concepts in the literature about the types of CERs and cost models indicate six categories of parametric application can be established: 1) CERs that are cost-to-cost, 2) CERs that are cost-to-non-cost, 3) commercial models that estimate the entire cost of a proposal, 4) commercial models that estimate only significant portions of a proposal, 5) in-house models that estimate the entire cost of a proposal, and 6) in-house models that estimate only significant portions of a proposal.

Purpose of Estimate. The previous sections categorized estimates based on the methodology used. Types of estimates can also be categorized based on the intended purpose of the estimate. Remer lists the three purposes as definitive, budgetary, and order of magnitude, in descending order of certainty (Remer and Buchanan, 1993:8).

A definitive cost estimate is used during the more mature portions of a production program, when a firm design exits. The estimate is based on the firm design and schedules that are clearly defined (Remer and Buchanan, 1993:9). Actual cost information or cost history is available to create the estimate. Therefore, a definitive cost estimate is produced using the cost build-up methodology discussed previously.

Budgetary cost estimates are used during the development portion of a program, where there is an overall system functional requirement with at least preliminary deliverable, receivable, and schedule information presented for the requirement (Remer and Buchanan, 1993:9). With a sufficient degree of design definition, judgments can be made about similarities between the product to be developed and existing products. A budgetary estimate can be produced using the analogy method of cost estimation.

The Order of Magnitude, or rough order of magnitude (ROM), cost estimate is developed early in a program during the requirements definition stage. Only preliminary information about the requirement and the deliverables is available at this stage (Remer and Buchanan, 1993:9). The estimate is produced using a minimal set of inputs to characterize key cost drivers using a parametric method of cost estimating. The literature suggests that parametrics are the primary means of developing an estimate early in the program (Black, 1987:1).

Accuracy. Addressing the subject of relative accuracy between parametric estimating models and more conventional estimating techniques is difficult. An objective direct comparison would involve evaluating, over time, the actual final costs against the estimated costs using both parametric and conventional methodologies. The literature is void of any such objective comparisons, probably because of the costs associated with preparing and administering dual estimates. Estimation performance benefits from learning but as research on estimation practices and accuracy suggests, there is little motivation to increase learning in this area (Ogunlana, 1991:133). Estimation performance is considered adequate because there is no evidence to the contrary. This is because a system does not exist which would require regular monitoring of estimation performance (Ogunlana, 1991:133; Lewis and Pearson, 1977:2). A structure that could determine the accuracy of estimates and identify the reasons for inaccuracies would be an effective aid but appears difficult to institutionalize. In the past, workload priorities, personnel mobility, and accounting systems have created barriers to creating such a structure. Without a structure to measure the accuracy of an estimate, there cannot be a structure to objectively compare the relative accuracy of parametric estimates to conventional techniques. The literature therefore discusses relative accuracy between parametric and conventional techniques from at least four subjective perspectives: 1) the historical accuracy of the estimated cost, 2) the maturity of the effort being estimated, 3) the resources devoted to produce an estimate, and 4) the techniques used to provide more accurate estimates.

Historical Accuracy. The literature suggests that estimating has not been as accurate as desired. In the 1970's, the big concern was cost growth, specifically the big difference between the final cost and the initial estimate (Lewis and Pearson, 1977:2). The General Accounting Office (GAO) estimates 67 percent of programs overrun by more than 100 percent based on the unavailability of adequate technical information (Gardner and Passarello, 1981:2). Strangely, nothing is stated about the overrun in terms of the nature of the initial estimate and how it was estimated. Another study of computer managers suggests only 25 percent of the projects complete close to their estimates (Lederer, 1992b:86). From another perspective, Remer's study of technically advanced commercial energy and chemical programs found final costs exceed initial estimates by an average of 104 percent (Remer and Buchanan, 1993:7). While it is easy to see that initial estimates are not as accurate as desired, it is difficult to determine what the estimates referred to and how they were derived. History supports the need for more accurate estimates. The following perspectives suggest factors that affect the accuracy of an estimate.

Maturity of Effort. The maturity of any effort has been shown to influence the accuracy of the estimate. It is more difficult for an estimate prepared for the conceptual phase of a program or an estimate prepared for a preliminary budget to compete in accuracy with an estimate prepared for a production phase or an estimate prepared for a funds authorization requirement. The information that is available at those points in the acquisition process explains the difficulty in achieving the accuracy (Lewis and Pearson, 1977:2).

Research has shown that there is an expected level of accuracy based on final costs relative to the initial estimates as depicted below (Remer and Buchanan, 1993:8; Chopey, 1994:106):

Type of Estimate and Information Available	Level of Accuracy
Definitive, Detailed	- 5% to +15%
Budgetary, Preliminary	-15% to +30%
Order of Magnitude, Conceptual	-30% to +50%

Estimating accuracy improves over time as the product matures. Information used to estimate the cost of an item never before designed or built differs greatly from the information available and used to estimate the cost after producing the item. During concept exploration, the best available information may be physical and performance characteristics of the item. During production, the best available information may be the previous costs of production.

Resources Devoted. The effort expended to produce an estimate has been shown to influence the accuracy of the estimate. The Remer study is often cited when reviewing the resources expended versus accuracy trade-off. Remer saw that frequent overruns were caused by the lack of resources spent to do proper up-front estimating and by the lack of implementor involvement in the estimating process (Remer and Buchanan, 1993:9). A quantifiable relationship could be established between accuracy and the amount of resources available to prepare the estimate, defining the cost of preparing an estimate as a percentage of the cost of the item. Increasing levels of accuracy cost more resources, regardless of business type, estimate type, or dollar value (Remer and Buchanan, 1993:26). Results from Remer's research indicated that budget estimates cost

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2.5 times as much as order of magnitude estimates and definitive estimates cost 5 times as much as order of magnitude estimates (Remer and Buchanan, 1993:9).

A related study by Larsen implies a relationship between profitability and estimating accuracy (Larsen, 1994:25). A simulation was created using two companies making competitive bids. One company used Remer's guidelines for determining the amount to invest in proposal preparation to achieve an accuracy level for a definitive estimate and the other company spent far less on its estimate. The results indicated two companies of similar size, market share, and cost structure will have substantially different average total profits, 17 percent versus 2.6 percent, based on three causes (Larsen, 1994:26). The accurate estimating company will seldom have negative profits and will also earn very high profits more often (Larsen, 1994:26). The inaccurate estimating company will have negative profits on most of its awarded efforts (Larsen, 1994:26). The point of Larsen and Remer's study is that if the proper amounts of resources are not devoted to preparing an estimate, the result will be greater inaccuracy and reduced profitability. Many parametric models are used to make rapid ball-park cost estimates of both recurring and nonrecurring manufacturing cost during initial design phases (Philpott and others, 1996:256). Parametrics is generally perceived to be more effective in cost and time requirements than other forms of estimating (Hargrove, 1985:7). While cost effective estimates were not quantified in terms of accuracy to cost, it is difficult to debate the issue that parametric estimates are quicker and cheaper to prepare. When the quicker, cheaper view of parametrics is combined with Remer and Larsen's findings, there is an

inference that quick and cheap parametrics are less accurate. Parametric estimates may initially cost less but the trade-off may be less accuracy.

Techniques to Provide More Accurate Estimates. The literature provides guidelines for preparing better cost estimates which do not necessarily advocate parametric estimating as more accurate. Among them are:

-Assign the initial estimating tasks to the final developers.

-Delay finalizing the estimate until the end of a thorough study.

-Anticipate and control changes.

-Rely on documented facts, standards, and simple arithmetic formulas.

-Do not rely on cost estimating software for an accurate estimate.

(Lederer, 1992a:57)

Even though a clear comparison cannot be made between the accuracy of conventional estimating versus parametric estimating, the literature suggests that parametric estimating may not be as accurate as other methods. The historical accuracy of initial estimates has not been very good when compared to final cost. As programs mature and more information is available, the proper use of that information leads to increased estimating accuracy. Conventional methods make better use of current information by using actual costs of previously built items to estimate the costs of the next essentially identical item. The more resources put into an estimate, the more accurate an estimate is going to be (Remer and Buchanan, 1993:8). Parametric modeling may be a resource saver, but failure to use the more current available information to prepare an estimate will likely cause estimating inaccuracies and the associated program perturbations. Conventional

estimating methods use the full range of available resources to develop the estimates. Certain techniques lead to more accurate estimates. This includes waiting as long as possible to make the estimate and getting as many people involved as possible. This again tends to favor conventional methods over parametric modeling in terms of accuracy.

Risk Analysis. It is impossible to discuss estimating accuracy without discussing risk. The abundance of literature in this area reflects the importance of risk analysis. The 1997 Journal of Cost Analysis contains a bibliography on the topic listing fifty documents on the subject of estimating risk and how to develop and quantify it (Black, 1997:61).

Risk exists with any type of prepared estimate using any type of methodology. Risk assessment in parametrics is important because of the black box nature of many parametric model predictions. The term *black box* in this context refers to providing an input to a model and getting an output without having an understanding of the mathematical algorithms that produced the output. Estimates are made at the aggregate level, not on a task by task basis so there is little visibility into what makes up the prediction. Conventional approaches, however, allow intuitive risk assessments to be made about the quality and accuracy of the estimates. Proper implementation of parametric modeling should include formal risk analysis.

Historically, cost estimating risk has contributed less to the cost growth of weapon systems than schedule or technical risk (Biery and others, 1994:62). However, current research suggests that estimating uncertainties do account for about 25 percent of

program cost growth (Biery and others, 1994:62). Sources of the uncertainty in parametric estimating techniques include the imprecision associated with the specific technique used, and input errors and oversights (Biery and others, 1994:60). Another error source exists with the historical data bases. Uncertainties are created both with the applicability of the data and in the normalization of that data.

Industry appears to understand the need for risk analysis as shown in the following statement. "Parametric cost estimating is often used in predicting the cost of something complex that has never been built before. Risk analysis attempts to establish a range for this estimate or a feeling of confidence in it" (Black, 1987:1). However, government contracting has been lacking in the use of formal risk analysis despite a 1982 acquisition improvement initiative to push the budget to most likely cost and apply quantitative risk techniques (Biery and others, 1994:57).

Utility of Parametric Models. The next sections discuss when parametric techniques should be used and how useful parametrics methods are in cost estimation? Based on research in the literature, the utility of parametric estimating focuses in the following areas: 1) intended purpose of the estimate, 2) overall customer acceptance, including training and comprehension, and 3) data and databases.

Intended Purpose. Research shows that the intended use of the more complex parametric applications is during the early program phases when time and resource constraints are the dictating factors (Philpott and others, 1996:257). Parametrics is "perceived to be more effective in cost and time than conventional estimating" (Parametric Cost Estimating Course Manual, 1987:5). Some contractors use parametrics

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estimates to test the estimates that were prepared using conventional techniques. Others use parametric models as the prime source of the estimate, and create details to match for submission as cost or pricing data to the government (Hargrove, 1985:9).

A cost build-up proposal states every task that is going to be accomplished with a value attached to each of those tasks. As a result, cost build-up proposals become detailed plans for accomplishment of a project or modification (Mann, 1997). The review of a cost build-up proposal provides insight into how the contractor plans to accomplish a task and the importance placed on certain tasks. Since parametric proposals have been generally used for conceptual and planning estimates, the absence of this detailed plan is not missed (Mann, 1997).

<u>Customer Acceptance</u>. Training aids in the understanding or comprehension of parametric models. In turn, this comprehension is necessary for customer acceptance. It is important to understand the initial effort in creating a parametric estimate in order to gain acceptance from the customer (Stanley, 1981:1). The benefits to be derived from parametric estimating cannot be realized until the models are understood and accepted as a reliable prediction of cost (Executive Summary, 1997a:10). Industry has noted that the "biggest challenge to the effective implementation of parametrics is the lack of familiarity with parametric estimating concepts on the part of the program and government oversight personnel" (Lubell, 1997:8).

Formal training is one aspect in achieving a successful comprehension level of parametric estimating techniques and models. However, training must also focus on four key areas to ultimately lead to customer acceptance. These are: 1) know the model, 2)

know the program, 3) know what has been done, and 4) support the customer (Stanley, 1981:1).

Basic training in things like making inputs into a parametric model is just scratching the surface of developing a good parametric estimator (Philpott and others, 1996:256). The estimator must understand the operation of the model to be able to sufficiently address any questions about the model. The relationship between the input and output data and how to analyze that data must be clearly understood (Stanley, 1981:5). It is necessary to focus on and identify any key cost drivers which change the costs significantly with only minor variations in inputted values (Stanley, 1981:2). It is also important to understand the relationship between product design parameters, key process parameters, and process costs (Philpott and others, 1996:257). The goal is that enough comprehensible data is provided to the customer so that the customer can make decisions (Stanley, 1981:5).

Research has also shown that designers and engineers make the most effective parametric estimators based on their familiarity with the pertinent levels of technology and technical performance (Apgar and Daschbach, 1987:9). What they lack in parametric estimating experience is quickly replenished by the state of the art in estimating technology.

To achieve customer acceptance, a parametric model must also be credible. It is just as important to consider the customer's perception of the model's credibility as it is to consider model accuracy and efficiency (Smith and Mason, 1997:156-157). Management and customer confidence in parametric methods is widely recognized as a problem

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regardless of what parametric method is used (Smith and Mason, 1997:156). This is particularly true in firm business proposals, which must satisfy both management and the customer regarding what constitutes a proper methodology. In the cost build-up estimation technique, there is a credible audit trail of detailed work procedures and methods, materials, and schedules. This allows any assumptions made to be examined and produces a perception of accuracy. Parametric methods do not have this audit trail. They are employed because it is either not feasible or not cost effective to develop the detailed level of cost build-up. Therefore, in complex parametric models, the detailed relationships cannot be checked. Acceptance of the estimate must come from credibility of the model.

Data and Databases. Data is another major factor influencing the usefulness of parametric estimating techniques. A 1974 Rand Report identified the greatest limitation on the use of parametric estimating was the lack of cost data (Rose and High, 1974:6). Parametric models require a databank of credible cost information to include actual cost data as well as any technical or specification design information. The data must be in sufficient detail to identify the factors that influence cost (Geaney, 1997:30). By definition, parametric estimating predicts the cost of a new product by extrapolating from a historical database. Therefore, a major requirement to implement parametric estimating becomes the necessity for an accurate and substantial database (Dean, 1997).

One challenge in building a database is the need for more than just historical cost data to build useful cost estimating models. A correlation of the historical cost data to the related product characteristics is needed to derive the cost to non-cost relationships and

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derive estimates based primarily on product characteristics (Parametric Cost Estimating Course Manual, 1987:15). There is some question whether current accounting systems are structured to provide this type of cost data to product correlation.

Historical data can also be difficult to interpret because contractors organize data differently and inconsistently across multiple project databases. However, certain guidelines exist which can lead to a consistent format for categorizing historical data. Data from Cost Schedule Control Systems Criteria (C/SCSC) and the MIL-STD-1567 system can provide formatted sources of historical data for parametric estimating (Mathis, undated:375). Guidelines that establish procedures for data accumulation and exchange would make future parametric use more viable because the data used for the parametric models would be more universally accepted. Data is one of the main concerns of the PCEI.

The Parametric Cost Estimating Initiative

Early in 1994, parametric practitioners met to evaluate why there was not a greater use of parametric estimating in DoD and NASA proposals; to identify barriers to the expanded use of parametrics; and to take advantage of any identified opportunities (DoD, 1995:8). It was quickly determined no formal barriers existed in implementing parametric estimating in Government contracting (Hertling, 1998:9). However, there were issues that needed to be addressed and as a result the Parametric Cost Estimating Initiative was established.

The PCEI began in April of 1994 with the formation of a joint government/industry working group. Action items established by the working group were to expand the use of parametric estimating techniques for government proposals; achieve recognition that parametrics is an acceptable method of cost estimating; and establish reinvention laboratories to test the expanded use of parametrics (Hertling, 1998:10). The PCEI has been successful in obtaining industry and government senior management support and encouragement. Both the Director of Defense Procurement and the Principle Deputy Assistant Secretary (Acquisition & Management) have supported the use of parametric cost estimating techniques (Spector,1995:1; Druyun, 1997:1). Other accomplishments include the preparation and distribution of the Parametric Cost Estimating Handbook, the PCEI newsletters, recommendation of formal training requirements, and periodic workshops (Hertling, 1998:16-19).

The reinvention laboratories were sponsored in December 1995 by the Director of DCAA and the Commander of DCMC. The primary objectives of the labs were to expand, test, and provide feedback and recommendations on the use of parametric estimating (Hertling, 1998:20). Thirteen sites were chosen to form integrated product teams (IPTs), consisting of contractors, major buying activities, DCMC, and DCAA. These sites include four from Boeing, three from Lockheed Martin, two from Northrop, two from Raytheon, GE Aircraft Engines, and Motorola Space & Systems (Hertling, 1998:21). The 1997 PCEI Newsletter advertises successful testing of the use of parametric techniques by the reinvention labs. "These teams are demonstrating that the use of parametrics results in improved customer satisfaction through better estimates;

reduced contract award cycle time; and significant reductions in proposal preparation, evaluation, and negotiation costs" (Collins and Eck, 1997b:1).

However, as of May 1997, there had been no procurements at the Aeronautical Systems Center, Wright Patterson AFB (WPAFB) that used the types of parametric techniques promoted by the PCEI (Anderson, 1997:1). If parametric estimating is more efficient and equally accurate, there should be evidence of rapid and widespread adoption of its use. Yet in the three years since the PCEI was formed, there have been no parametric implementation successes at a major contracting center of the Air Force.

Summary

Significant effort to expand the use of parametric estimating into DoD contracting continues because the current processes are still considered inefficient. It is also believed that parametric estimating is a better way of preparing an estimate combining accuracy and efficiency. These and related assertions are causing the expenditure of extensive resources to expand the role of parametric estimating in the contracting arena. If parametric estimating is inappropriate for the purposes planned, then the resources currently being devoted to implementing it are being wasted. The improper use of parametric estimating could lead to inaccurate estimates causing additional wasted resources, improperly funded programs, and associated acquisition perturbations.

The appropriate cost estimating technique according to the situation is important because the best methodology should lead to better results (i.e. less cost estimation error). Cost estimates are one of the keys for establishing program plans of execution. While it

is difficult to place an exact dollar amount on the value of a good estimate, the importance of properly performed cost estimates at all stages of the acquisition cycle cannot be overstated. The purpose of this study is to evaluate the efficacy of parametric cost estimating by comparing its perceived utility across users and contractor groups.

III. Methodology

Chapter II reviewed the literature with regard to how cost estimating is currently understood and accomplished. Chapter II provided generalizations about parametric estimating and the selection of estimating methods. Chapter II also introduced the PCEI and presented its goals and objectives. The PCEI advocates a position that parametrics can not only shorten cycle time but also provide equivalent as accuracy as the more conventional bottoms-up techniques. The literature proposes that parametrics is primarily used early in a program when time and information is limited. Whether customer viewpoints are consistent with the literature or the PCEI position is uncertain. Research is required to make this determination. Chapter III contains the methodology employed to conduct this research.

The overall objective of this research is to identify differences in perspectives about parametric estimating that exist between important users of parametric techniques. We need to know if PCEI members have a different perspective of parametric estimating than buying offices, and whether industry and government have differing views. To accomplish this, a qualitative study will be used.

Qualitative Research

Research Definition and Goals. Qualitative research is any kind of research that analyzes and produces findings about data that cannot be expressed in quantitative terms or numbers (Tesh, 1990:2-3). Qualitative research is mainly concerned with the nature of

a phenomena putting emphasis on processes and meanings - producing more detailed data about a smaller number of people and cases (Labuschagne, 1996). Qualitative research seeks to describe rather than quantify.

Marshall and Rossman establish guidelines for qualitative studies (Marshall and Rossman, 1991:Ch 3). Included is research that delves into complexities and processes and research that seeks to explore where and why policy and practice do not work (Marshall and Rossman, 1991:46). Policy makers need to see the impact of their policy. Qualitative research can evaluate the problems, identify the areas that can be influenced by the policy maker, and show the consequences of policy intervention (Marshall and Rossman, 1991:16).

Research can be classified into goals of exploration, description, prediction, explanation, and action (Dane, 1990:5). Exploratory research "involves an attempt to determine whether or not a phenomenon exists" (Dane, 1990:5). Through exploration, patterns can be uncovered as well as concepts more clearly developed. One purpose is to discover important questions, processes, and relationships (Marshall and Rossman, 1991:43). Exploratory research can also identify important variables for future research (Marshall and Rossman, 1991:15).

Application of Research to Data Gathering. This study lends itself to qualitative research. This research is an exploratory evaluation of the perspectives of parametric estimating within the defense acquisition community. The research will gather data to try and isolate the important questions about parametric usefulness. Parametric estimating has been established as a very broad area in the general field of cost estimating.

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Parametric estimating involves techniques ranging from very basic to very complex. Exploratory research will determine whether consensus exists between differing groups on when particular applications of parametric should be used and why. For example, there is not a current source of information that stratifies the different parametric techniques according to different phases of a program or availability of information. Data needs to be gathered on the subject of the appropriateness of use of different parametric applications.

From the literature review, there is a possible difference between the views advocated by the PCEI and the traditional established view on the intended purpose for parametric applications. The literature suggests using parametrics to estimate something which has never been built before, whereas, the PCEI may be suggesting that parametrics could be a better way to estimate across the entire procurement cycle. Since the PCEI is a joint government and industry initiative, participants are both government and industry people. Do the government and industry PCEI participants actually see parametric estimating in a similar manner? It is also worthwhile to know whether non-PCEI government and industry groups see parametric estimating similar to the traditional view or more consistent with the PCEI perspective. Data needs to be gathered on the utilization of parametric models and the perceptions of the usefulness and accuracy of parametric applications.

In general, our study investigates the following questions:

1) Has the use of parametric estimating increased and is more effort needed to increase its use?

2) What are some of the perceived barriers to implementation?

3) Do different acquisition groups have different perceptions on the accuracy of parametrics?

4) How useful is parametric estimating to government contracting as influenced by phase of the acquisition cycle, perceived accuracy, and perceived utility?

5) Is there a difference in the perceived accuracy and usefulness of the six types of parametric applications?

There is reason to believe that customers may have a different view of using parametric techniques than those who prepare the parametric proposal estimates. The literature suggests that there is possibly a relationship between the customer's degree of acceptance of a parametric estimate and such things as: the customer's perception of the estimate's accuracy, the level of training in parametric estimating and the model being used, and the model's credibility. Data needs to be gathered on the subject of customer perceptions of the use of parametrics. It follows that a comparison of PCEI and customers perceptions would also be very worthwhile.

Acquiring an understanding of what is really going on in something as complicated as a DOD acquisition streamlining initiative invariably involves more than just reading a few documents. A boilerplate label like "expand the use of parametric estimating" can be deceiving if compared to actual practice. This is especially true if one were tasked to judge the goodness or benefit that a streamlining initiative might provide. Information needs to be gathered on the subject of what the PCEI is really doing, not at the summary level, but at the grassroots level. This information could provide a scientifically based determination of the potential benefits, detriments, and impediments of this change in

how we price DoD acquisitions. Questions need to be answered like what basic differences in proposal preparation and negotiation processes may come out of this initiative and what gains and/or losses might those changes provide to the acquisition process.

Research Design

Review of Methodology. The research strategy to gather data uses a mixture of methodologies characteristic of qualitative research. Cooper and Emory list several exploratory techniques which can be relied upon to gather data. These include: in-depth interviewing; participant observation; films, photographs, and videotape; projective techniques and psychological testing; case studies; street ethnography; elite interviewing; document analysis; and proxemics and kinesics (Cooper and Emory, 1995:118). Marshall and Rossman also include questionnaires and surveys, historical analysis, content analysis, and unobtrusive measures (Marshall and Rossman, 1991:83).

This study will combine the different data collection techniques involved in historical analysis, questionnaires, and interviews. Multiple methods will be used to compensate weaknesses in one strategy with strengths in another. While not a perfect approach given the exploratory nature of this study, we should be able to gain valuable insight into the underlying value of parametric techniques as they apply to DoD contracting.

Collection of Data. Historical analysis is "a method of discovering, from records, what happened in the past" and is particularly useful "for establishing a baseline or

background" (Marshall and Rossman, 1991:95). There is a great deal of information about the PCEI which can provide a progression of the PCEI and its past and current accomplishments. First is the PCEI newsletter that is published periodically and provides summary level information on accomplishments at specific lab sites. This information will be reviewed and analyzed.

A unique opportunity will present itself in early March 1998. The PCEI, in conjunction with the International Society of Parametric Analyst, will hold its annual conference in Los Angeles, California. Since there will be 400 to 500 people associated with the PCEI at the conference, this will be an excellent opportunity to gather an abundance of information on parametric implementation strategies and specific accomplishments. We will use this conference as a data gathering opportunity.

A compilation of PCEI member ideas, attitudes, and perceptions would be invaluable. The best way to accomplish this would be to administer a questionnaire. A questionnaire is administered to "learn about the distribution of a characteristic or set of characteristics or a set of attitudes or beliefs" (Marshall and Rossman, 1991:83). The purpose of a survey is to "use questionnaires or interviews to collect data from participants in a sample about their characteristics, experiences, and opinions in order to generalize the findings to a population" (Gall and others, 1996:289). However, the amount of time available until the conference is insufficient to properly develop a construct valid survey.

Preparing a study with construct validity involves accepted ideas such as establishing a focus group, running a pilot study, and validating constructs (Churchill,

1979:66). In lieu of developing this validated survey instrument, the researchers prepared a list of items based on information from the literature review, and provided the items to five available topic experts for review. Four experts were at Aeronautical Systems Center and one at DCAA headquarters. The topic experts were requested to review the survey instrument to see if: the questions were clearly understood; if there were any obvious errors; and if there was anything they would add considering the topic at hand. Errors were corrected and items considered redundant or confusing were deleted and/or corrected. The final questionnaire instrument is included in Appendix A.

The questionnaire will be taken to the conference and announced early in the first day of the two day conference. Participation will be strictly voluntary. Blank questionnaires will be available at a prime location near the entrance to the conference ballroom. Boxes will be provided for completed surveys at the same location.

The questionnaire will provide a needed means of reaching a large number of people on some of the obvious questions. The conference will also provide the opportunity to conduct interviews. Because of the compressed and intense pace of the conference, it is expected that the number of interviews will be relatively small.

The questionnaire will attempt to gather experience data on five basic areas: 1) expanded use of parametric estimating, 2) utility (accuracy, acquisition phase, contract type), 3) parametric applications, 4) challenges or barriers, and 5) demographic information.

Defining the Research Concepts to be Explored. The first research concept to be defined is that of expanded use of parametric estimating. Nothing is clearer about the

stated goal of the PCEI than to expand the use of parametric estimating. The concept of expanded use should mean that in contractor proposals for use in establishing firm contract prices, parametric techniques should be more prevalent, if not the sole means of estimating the cost or price of the proposal. The mention of firm contract proposals is in contrast to those parametric applications that are used to derive rough order of magnitude (ROM) or budgetary estimates for planning purposes. Firm contract proposals does not imply firm fixed price type contracting arrangements, only that the parametric estimate was derived for the purpose of establishing a contract price for some provided good or service.

Perhaps the most difficult concept to be defined in this research exploration is that of utility of parametric estimates. Utility is defined as fitness for some purpose or worth to some end (Webster, 1984:1300). The difficulty in applying this textbook definition is determining the fitness or worth variables and their relative importance. Utility is therefore a perceived value in something. Not only will there be different perceptions in overall utility of something, but there will be differences in perceptions in what defines utility in relative importance of the attributes being considered. For example, to some the utility of parametrics may be based on how accurately it derives an estimate, to others, how easily or quickly it derives an estimate, and to others, how versatile parametric estimating is in deriving estimates in particular situations. In Apgar's discussion of advantages and disadvantages of conventional and parametric estimating, issues such as ease of use, efficiency of use, requirements for special training, amount used, degree understood and accepted, and amount of input detail required are proposed (Parametric

Cost Estimating Course Manual, 1987:126-129). These issues help to identify the variables of fitness or worth in Webster's definition of utility. These ideas form the basis of the research concept of utility to be used in this thesis. In this exploratory research, the variables of utility are weighted equally in developing overall utility measures since there is no accepted basis to provide weightings. This research will investigate the concept of utility of parametric estimating from the perspective of parametrics as an aggregate term and from the perspective of specific parametric applications.

This research has stated before and will again, parametric estimating is an all-encompassing term for a variety of techniques that develop estimated amounts in a manner more statistically sound than just experience or judgment or other non-quantifiable methods. For lack of any better structure, this research has already classified parametric estimates according to six types: 1) CERs that are cost-to-cost; 2) CERs that are cost-to-non-cost; 3) commercial models that estimate the entire cost of a proposal; 4) commercial models that estimate only significant portions of a proposal; 5) in-house models that estimate the entire cost of a proposal; and 6) in-house models that estimate only significant portions of a proposal. To try to measure the utility of parametric estimating as a general practice may be somewhat in error because the utility of each of the applications could possibly be different. This research will explore the possibility of this by seeking responses to six identical questions on the six different applications (Section 3 of Appendix A). The six questions deal with the utility aspects of efficiency of use, ease of use, accuracy, frequency of use, and versatility of use.

The last concept to be explored is that of barriers or challenges to using parametric estimating. While this is somewhat redundant to the concept of expanded use, it differs because it offers a much wider variety of specific possible causes. Many of the potential causes were identified by the PCEI itself and some are developed by the researchers based on experience or knowledge gained from the literature review.

Purposeful Sampling. While the questionnaire instrument does not meet requirements to establish construct validity and provide data from which quantitative conclusions can be drawn, it does provide a database of experience data that includes demographic differentiation. Differing cell demographics can express the things different groups believe to be important. The data gathered from the parametric annual conference will reflect the perspective of the PCEI members, because the attendees have some association to parametric estimating.

Gathering similar information from customer oriented acquisition people not associated with the initiative will involve providing the questionnaire to selected acquisition personnel who have familiarity with parametric estimating. Since the practice is not used extensively in proposals that establish firm contract prices, the population of contracting people who can provide knowledgeable opinions is limited. A sample will be developed based on the researcher's knowledge of contracting officer experiences. Additionally, the ASC business clearance reviewers are knowledgeable about who has been involved in parametrically based proposal efforts and their input will be sought on appropriate candidates to request questionnaire input. The researchers consider the idea of random sampling inappropriate for this exploratory research since the objectives are to

derive some ideas on differences in perceptions on the use of parametrics. Someone who does not know what parametric estimating is, at the level of a working understanding, provides no contribution to the accomplishment of this objective. Customer inputs will also be sought from ASC Price Analysts, believed to be as knowledgeable about the subject as any group at ASC. It is also important to gain input from intermediate customers like Defense Contract Management Command (DCMC) and Defense Contract Audit Agency (DCAA). These intermediate customers are responsible for initial proposal evaluation and approval of estimating systems that produce all estimates. DCAA and DCMC are similar to ASC in that the actual number of people knowledgeable and experienced in parametric estimating is believed to be fairly small. In general, the questionnaire sample size of non-PCEI will likely not be very large since the researchers are seeking customers with a working understanding of parametric estimating.

Data Analysis

The data analyses used for exploratory research tend to be general. Often used are qualitative analyses or "nonnumerical analyses concerning quality rather than quantity" (Dane, 1990:235). Qualitative analysis organizes data in a manner to discover patterns, themes, forms and qualities found in the raw data collected (Labuschagne, 1996). Gall, Borg and Gall identify several techniques known collectively as "exploratory data analysis, which is a method for discovering unforeseen or unexpected patterns in the data and consequently for gaining new insights and understanding of the natural phenomena"

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(Gall and others, 1996:197). A part of exploratory data analysis is the use of descriptive statistics.

Descriptive statistics are "mathematical techniques for organizing and summarizing a set of numerical data" (Gall and others, 1996:175). There are three main groups of descriptive statistics: frequency counts and frequency distributions, graphical representations of data, and summary statistics (Graziano and Raulin, 1989:87). Graziano and Raulin summarize the three groups as follows:

> Descriptive statistics help us to summarize and describe large quantities of scores in only a few numbers. They are a vital first step in interpreting research data. Even when more complicated research designs are used, describing data will always be the first step in any data-analysis procedures. Frequency distributions and graphical representations of data are often helpful. Summary statistics simplify data further. There are summary statistics to indicate the typical score (measures of central tendency), including the mean, the median, and the mode. There are summary statistics to indicate the variability of the scores, including the range, the variance, and the standard deviation. Finally, there are descriptive statistics to indicate the degree of relationship between two or more variables (correlations). (Graziano and Raulin, 1989:106)

This study will use exploratory data analysis, using both qualitative analysis and descriptive statistics techniques to evaluate the research questions.

Summary

This research effort is designed as an exploratory, qualitative study concerning the perspectives of parametric estimating within the defense acquisition community. A mixed methodology of historical analysis, questionnaires, and interviews will be used to determine the differences in perspectives about parametric estimating and between whom

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the differences exist. The exploratory data analysis techniques used will assist in our

investigation of the research questions.

IV. Results and Analysis

Introduction

This chapter provides the results of the data collection and analysis process outlined in Chapter III. An overview of the questionnaire demographics is presented. Results are then presented and discussed in detail.

Overview of Questionnaire Demographics

The questionnaire results were categorized into four acquisition groups: PCEI Industry, PCEI Government, Non-PCEI Industry, and Non-PCEI Government. Figure 1 provides the total returns broken out by acquisition groups.
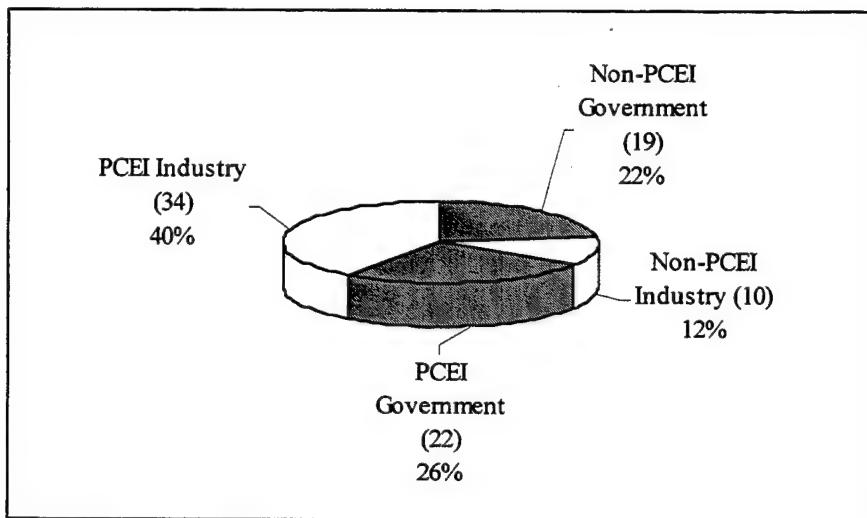
Figure 1. Questionnaire Returns by User Groups

The results from the PCEI industry and government acquisition groups were received in March 1998 during the PCEI Conference. Fifty-seven questionnaires were returned during the conference. One questionnaire was discarded because no

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demographic information was provided. Ten other questionnaires contained some missing data but were used when possible to answer the investigative questions. Thirty-four questionnaires were analyzed from the PCEI industry acquisition group and 22 from the PCEI government acquisition group.

A total of 31 questionnaires were received from the Non-PCEI acquisition group during June 1998. Two were discarded when no demographic information was provided. Two other questionnaires contained missing information, but like above, were used when possible to answer the investigative questions. For the Non-PCEI acquisition group, 10 questionnaires were analyzed from industry and 19 questionnaires from government.

While other demographic information was requested, the only information used was to distinguish between the four parametric acquisition groups. Since this is a qualitative study, no attempt was made to correlate any of the demographic information with the item responses.

Questionnaire Overview and Results

The questionnaire included five sections: 1) Expanded use of Parametric Estimating, 2) Utility - Accuracy, Acquisition Phase, Contract Type, 3) Parametric Applications, 4) Main Challenges or Barriers, and 5) Demographic Information. The questionnaire is included in Appendix A. Sections 1 - 3 were designed using a five point likert scale from "Strongly Disagree" to "Strongly Agree." Items from these sections were used to answer investigative questions one, and three through five. Several items were designed to be answered in the opposite direction and those will be identified with the applicable

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investigative question. The responses concerning investigative question two comes from Section 4 of the questionnaire and does not use the likert scale. Under each investigative question, "S" refers to the section of the questionnaire and "Q" refers to the question number.

Investigative Question One: Has the use of parametric estimating increased and is more effort needed to increase its use? Investigative question one looks at both the actual increase in use of parametric techniques and whether more effort is still needed to increase the use of parametric estimating. The intent of the first part of investigative question one is to evaluate if the four acquisition groups perceive an increase in the use of parametric techniques. The second part addresses whether the acquisition groups feel more effort is needed to increase the use of parametric techniques. The following items from the questionnaire were used to evaluate whether there has been an increase in use of parametric techniques.

S1Q1: The use of parametric techniques has increased in the past 3 years.

S1Q2: The government and industry have been successful in expanding the use of parametric estimation.

Table 1 provides the results for these questions.

For S1Q1, the data indicates a large majority of the respondents either agree or strongly agree that there has been increased use of parametric techniques within the past three years, ranging from 74 percent for Non-PCEI Government to 90 percent for Non-PCEI Industry. The PCEI groups responded with 85 percent and 77 percent agreement for industry and government, respectively. For S1Q2, only Non-PCEI Government had a

lower than 60 percent agreement that government and industry have been successful in expanding the use of parametrics. Only 32 percent of Non-PCEI Government responded positively to this question.

Table 1. Responses to Questionnaire Items for Investigative Question One (Has use increased?).

Item	n	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree	Mean
PCEI –Industry							**4.00**
S1 Q1	34	0.000	0.000	0.147	0.441	0.412	4.26
S1 Q2	34	0.000	0.059	0.265	0.559	0.118	3.74
PCEI – Govt							**3.73**
S1 Q1	22	0.045	0.045	0.136	0.545	0.228	3.82
S1 Q2	22	0.045	0.091	0.182	0.545	0.136	3.64
Non PCEI – Industry							**3.65**
S1 Q1	10	0.000	0.100	0.000	0.700	0.200	4.00
S1 Q2	10	0.000	0.300	0.100	0.600	0.000	3.30
Non PCEI – Govt							**3.47**
S1 Q1	19	0.000	0.053	0.211	0.579	0.158	3.84
S1 Q2	19	0.000	0.211	0.474	0.316	0.000	3.11

The following items from the questionnaire were used to evaluate if more effort is needed to increase the use of parametric techniques.

S1Q3:   More effort is needed by industry to expand the use of parametric estimating.

S1Q4:   More effort is needed by the Government to expand the use of parametric estimating.

S1Q5:   The use of parametric estimating techniques should be expanded in DoD contracts.

Table 2 provides the results for this question.

The data shows that, except for Non-PCEI Government, there is very strong agreement that more effort is needed to expand the use of parametric estimating and the

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use should be expanded in DoD contracts. Except for Non-PCEI Government, the level
of agreement is nearly or greater than 90%. The Non-PCEI Government responses
showed 63% agreement that more effort is needed, but only 37% agreed that the use of
parametric estimating should be expanded in DoD contracts.

Table 2. Responses to Questionnaire Items for Investigative Question One
(Is more effort needed?)

Item	n	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree	Mean
PCEI –Industry							**4.51**
S1 Q3	34	0.000	0.000	0.029	0.412	0.559	4.53
S1 Q4	34	0.000	0.000	0.059	0.353	0.588	4.53
S1 Q5	34	0.000	0.000	0.029	0.471	0.500	4.47
PCEI – Govt							**4.44**
S1 Q3	22	0.000	0.045	0.091	0.364	0.500	4.45
S1 Q4	22	0.000	0.000	0.000	0.455	0.545	4.55
S1 Q5	22	0.000	0.000	0.091	0.500	0.409	4.32
Non PCEI – Industry							**4.31**
S1 Q3	10	0.000	0.000	0.100	0.700	0.200	4.10
S1 Q4	10	0.000	0.000	0.000	0.600	0.400	4.40
S1 Q5	10	0.000	0.000	0.000	0.556	0.444	4.44
Non PCEI – Govt							**3.54**
S1 Q3	19	0.000	0.105	0.263	0.526	0.105	3.63
S1 Q4	19	0.000	0.105	0.263	0.579	0.053	3.58
S1 Q5	19	0.000	0.053	0.579	0.263	0.105	3.42

A comparison of the mean scores for *has use increased* (S1Q1 and S1Q2 combined)
and *is more effort needed* (S1Q3, S1Q4, and S1Q5 combined) is shown in Figure 2. A
mean score of 3.0 means neither agree nor disagree, 4.0 means agree, and 5.0 means
strongly agree. All four groups had a mean score above the neutral position, reflecting
some level of agreement that the use of parametrics has increased and that there is a need
for more effort to expand the use of parametrics. The responses were not strongly in

favor of that suggestion, just above the neutral response.

**Has Use Increased
Is More Effort Needed**
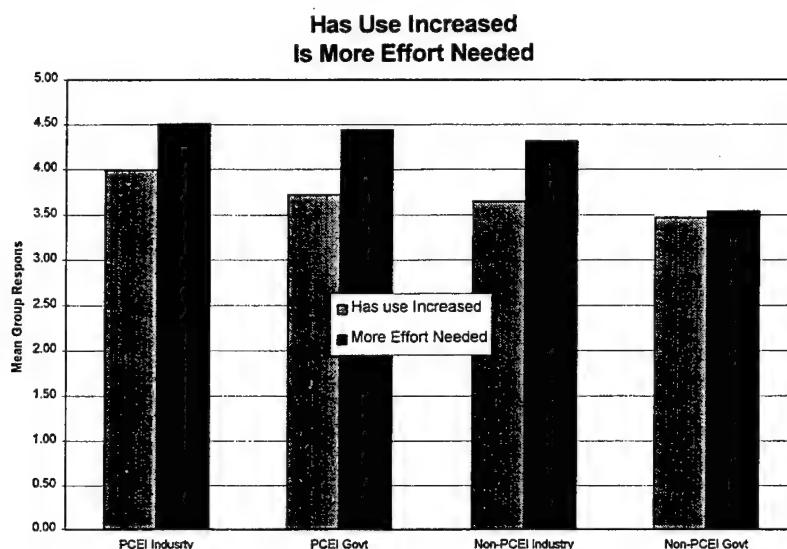
Figure 2. Mean Scores - Has Use Increased and Is More Effort Needed?

Both PCEI groups and the Non-PCEI industry group have similar responses

concerning the increased use of parametrics and whether more effort is needed to expand

the use of parametrics in DoD contracts. The Non-PCEI government group had the

lowest response score in both categories but was only noticeably lower about whether

more effort is needed.

Investigative Question Two: What are some of the perceived barriers to

implementation? Many potential barriers have been discussed by the PCEI. The intent of

investigative question two is to evaluate how the different acquisition groups perceive the

barriers to expand the use of parametrics.

Section 4 of the questionnaire was used to identify the main challenges or barriers to

parametric estimating. Respondents were requested to identify the top 5 challenges or

barriers. Since not all respondents were consistent in ranking the challenges 1 through 5, the challenges or barriers identified were merely counted the number of times they were identified as barriers. Table 3 provides the total count that each parametric barrier was listed in the top 5.

Table 3. Responses to Questionnaire Items for Investigative Question Two

Number of Times Noted as a Parametric Implementation Barrier (Combined TINA & Acquisition Rules and Utility & Difficulty of Use)				
	PCEI Industry	**PCEI Government**	**Non-PCEI Industry**	**Non-PCEI Government**
Data	29	16	5	11
Training	26	20	5	10
Accuracy	7	8	5	14
Risk Assessment	8	5	4	6
TINA/Acquisition Rules	15	7	14	9
Current Bus Environment	11	7	2	5
Other	5	4	1	0
Lack of Govt Support	23	7	9	8
Lack of Industry Support	21	7	1	7
Utility/Usefulness Difficulty	6	11	2	18
Model Development	23	12	4	14
Total Responses	174	104	52	102

The raw data of Table 3 is revised in Table 4 to provide a ranking system of the barriers to expanded implementation of parametric estimating. Three categories, risk assessment, current business environment, and other, were deleted because they were not rated highly by any of the four acquisition groups. The Truth In Negotiation Act (TINA) and acquisition rules were considered similar enough to be combined into one category as were utility and difficulty of use. The deletion and combination of items allows a better visualization of those potential barrier causes that can be considered important to the

different groups. The *Mean Ranking* is the average rank of all four acquisition groups and *Rank* is the ranking of the Mean Ranking. The results are shown in Table 4.

Table 4. Ranking Responses to Questionnaire Items for Investigative Question Two

Ranking Responses of Parametric Implementation Barriers					
	PCEI Industry	PCEI Govt	Non-PCEI Industry	Non-PCEI Govt	Mean Ranking	Rank
Data	1	2	3	4	2.5	1
Training	2	1	3	5	2.8	2
Accuracy	9	5	3	2	4.8	5
TINA/Acquisition Rules	6	6	1	6	4.8	5
Lack of Govt Support	3	6	2	7	4.5	4
Lack of Industry Support	5	6	10	8	7.3	8
Utility/Usefulness Difficulty	10	4	8	1	5.8	7
Model Development	3	3	6	2	3.5	3

The data on barriers can be interpreted based on both the average of all the group responses and on the differences between acquisition group responses. The data provides findings that are both intuitive and revealing.

All four acquisition groups identified data and training concerns as two of their top five challenges or barriers to implementing parametric estimating. The PCEI forecasted the importance of training to the parametric initiative, and training is one of the top ranked barriers from every group except Non-PCEI Government. A possible explanation for the low ranking of training by Non-PCEI Government may be the belief that the government is nearly adequately trained to deal with parametric estimates, or that training is available and will be obtained when needed based on the demands of the proposal situation. The high ranking of data and model development is something of a revelation. Apparently, the difficulty of obtaining and organizing the correct data and developing

parametric models with that data is a tougher job than originally envisioned or currently acknowledged because it was not one of the original barriers repeatedly discussed by the PCEI in the newsletter.

There are other noteworthy observations, most dealing with one or two group's difference in perceptions from other groups. The most glaring example is the Non-PCEI government and industry group perceptions of accuracy compared with PCEI government and industry groups. The PCEI confidence in the accuracy of parametric techniques does not seem to be shared by Non-PCEI groups. This will be discussed more in the sections of this thesis pertaining to investigative questions three and five.

Another example of group differences is the Non-PCEI Government high ranking for utility/usefulness/difficulty of use. The utility construct was defined in very broad terms in Chapter III and dealt with issues like acquisition phase, contract type, and ease of use. A discussion of the Non-PCEI's perceptions of utility are addressed in the sections pertaining to investigative questions four and five.

The last finding on barriers concerns the Non-PCEI Industry's high ranking of TINA/FAR rules and lack of government support. Section 4 of the survey provided the opportunity for respondents to write in barriers to expanded parametric use. A popular response was the FAR 15 requirement for subcontractor cost and pricing data. Non-PCEI Industry may perceive the government has an aversion to using parametric techniques to estimate the cost for subsystems that are purchased items. Government staff personnel who provide approval authority to negotiate and finalize procurement actions may still feel bound by what they believe to be hard requirements for subcontract pricing data.

This may be the cause of the high ranking for lack of government support by Non-PCEI Industry people, although other reasons may exist.

Investigative Question Three: Do different acquisition groups have different perceptions on the accuracy of parametrics? The intent of investigative question three is to determine if parametric estimating techniques are considered as accurate as other cost estimating techniques. The following survey items were used to determine the parametric users' view of accuracy:

S1Q9:   The need for accuracy limits expansion of parametric techniques.

S2Q10:   Parametric estimates are as accurate as traditional cost build up approaches on concept/budgetary estimates.

S2Q11:   Parametric estimates are as accurate as traditional cost build up approaches on mature program estimates.

S2Q12:   Parametric estimates are as accurate as traditional cost build up approaches in forecasting production costs.

S3Q5:   (six separate questions) CERs that are Cost-to-Cost provide benefits in accuracy; CERs that are Cost-to-Non-Cost provide benefits in accuracy; Commercial Models that estimate the entire cost of a proposal provide benefits to accuracy; Commercial Models that estimate only significant portions of a proposal provide benefits to accuracy; In-house Models that estimate only significant portions of a proposal provide benefits to accuracy; In-house Models that estimate the entire cost of a proposal provide benefits to accuracy.

Table 5 provides the results for these questions.

Item S1Q9 was inadvertently designed to be answered in the opposite direction, meaning, a higher response approaching five reflects negatively on parametric estimating. The overall mean score for each of the four acquisition groups reflects a recoding of the data for item S1Q9.

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Table 5. Responses to Questionnaire Items for Investigative Question Three

Item	n	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree	Mean
PCEI -Industry							**3.89**
S1 Q9	34	0.353	0.382	0.088	0.118	0.059	2.15
S2 Q10	34	0.000	0.059	0.059	0.471	0.412	4.24
S2 Q11	34	0.000	0.029	0.118	0.529	0.324	4.15
S2 Q12	34	0.000	0.029	0.118	0.529	0.324	4.15
S3 Q5 (CER Cost to Cost)	31	0.000	0.129	0.194	0.516	0.161	3.71
S3 Q5 (CER Cost to NonCost)	32	0.000	0.094	0.250	0.469	0.188	3.75
S3 Q5 (Commercial-entire proposal)	33	0.030	0.030	0.333	0.455	0.152	3.67
S3 Q5 (Commercial-portion)	30	0.000	0.033	0.233	0.533	0.200	3.90
S3 Q5 (In-house-portion)	33	0.000	0.030	0.333	0.485	0.152	3.76
S3 Q5 (In-house-entire proposal)	32	0.000	0.031	0.375	0.406	0.188	3.75
PCEI - Govt							**3.45**
S1 Q9	22	0.318	0.318	0.136	0.091	0.136	2.55
S2 Q10	22	0.000	0.045	0.409	0.455	0.091	3.59
S2 Q11	22	0.000	0.045	0.364	0.500	0.091	3.64
S2 Q12	22	0.000	0.091	0.318	0.455	0.136	3.64
S3 Q5 (CER Cost to Cost)	18	0.000	0.056	0.389	0.444	0.111	3.71
S3 Q5 (CER Cost to NonCost)	18	0.056	0.056	0.444	0.389	0.056	3.41
S3 Q5 (Commercial-entire proposal)	17	0.000	0.176	0.647	0.118	0.059	3.13
S3 Q5 (Commercial-portion)	17	0.000	0.118	0.647	0.176	0.059	3.25
S3 Q5 (In-house-portion)	16	0.000	0.125	0.563	0.250	0.063	3.33
S3 Q5 (In-house-entire proposal)	16	0.000	0.063	0.688	0.188	0.063	3.33
Non PCEI - Industry							**3.37**
S1 Q9	10	0.200	0.200	0.300	0.300	0.000	2.70
S2 Q10	10	0.000	0.200	0.100	0.700	0.000	3.50
S2 Q11	10	0.000	0.200	0.300	0.400	0.100	3.40
S2 Q12	10	0.000	0.100	0.200	0.600	0.100	3.70
S3 Q5 (CER Cost to Cost)	8	0.000	0.125	0.125	0.500	0.250	3.88
S3 Q5 (CER Cost to NonCost)	8	0.000	0.500	0.000	0.375	0.125	3.13
S3 Q5 (Commercial-entire proposal)	9	0.000	0.111	0.333	0.556	0.000	3.44
S3 Q5 (Commercial-portion)	8	0.000	0.125	0.625	0.250	0.000	3.13
S3 Q5 (In-house-portion)	9	0.000	0.111	0.556	0.333	0.000	3.22
S3 Q5 (In-house-entire proposal)	8	0.000	0.375	0.250	0.375	0.000	3.00
Non PCEI - Govt							**2.94**
S1 Q9	34	0.000	0.211	0.421	0.211	0.158	3.32
S2 Q10	34	0.000	0.105	0.368	0.526	0.000	3.42
S2 Q11	34	0.053	0.263	0.211	0.474	0.000	3.11
S2 Q12	34	0.000	0.211	0.526	0.263	0.000	3.05
S3 Q5 (CER Cost to Cost)	31	0.000	0.211	0.368	0.316	0.105	3.32
S3 Q5 (CER Cost to NonCost)	32	0.000	0.158	0.526	0.263	0.053	3.21
S3 Q5 (Commercial-entire proposal)	33	0.158	0.158	0.579	0.105	0.000	2.63
S3 Q5 (Commercial-portion)	30	0.053	0.368	0.474	0.105	0.000	2.63
S3 Q5 (In-house-portion)	33	0.053	0.263	0.579	0.105	0.000	2.74
S3 Q5 (In-house-entire proposal)	32	0.053	0.368	0.474	0.105	0.000	2.63

Using S1Q9 alone, the data indicates the four acquisition groups hold differing views about the accuracy of parametric estimating techniques. Seventy-four percent of the PCEI Industry respondents felt the need for accuracy did not limit the expansion of parametric techniques. In contrast, only 21 percent of Non-PCEI Government, 40 percent of Non-PCEI Industry, and 64 percent of PCEI Government shared this view.

S2Q10, 11, and 12 address accuracy as it relates to the various stages of the acquisition cycle. The results provide a similar picture to S1Q9. Of PCEI Industry, 85 to 89 respondents felt parametrics were as accurate as traditional techniques during all acquisition phases. In contrast only 26 to 53 percent of Non-PCEI Government, 50 to 70 percent of Non-PCEI Industry, and 55 to 59 percent of PCEI Government shared this view.

The PCEI Government group did not view parametric estimating accuracy as favorably as the PCEI Industry group. Sixty-four percent felt the need for accuracy did not limit the expansion of parametric techniques while 23 percent did see it as limiting. While between 55 to 60 percent of PCEI Government felt parametric techniques were as accurate as traditional cost build up approaches, the percentage agreement dropped when looking at the benefits of accuracy from the six different types of parametrics. The specific differences in the six types will be discussed in response to investigative question five.

The Non-PCEI Industry held similar views to the PCEI Government. Although 40 percent of this group felt the need for accuracy did not limit the expansion of parametric estimating techniques, 30 percent did feel the need for accuracy was limiting the

expansion. Between 50 to 70 percent of Non-PCEI Industry felt parametric techniques were as accurate as traditional cost build up approaches. Once again, the percentage agreement dropped when looking at the benefits of accuracy from the six different types of parametric estimates.

The Non-PCEI Government held the least favorable views concerning the accuracy of parametric estimates. Only 21 percent of Non-PCEI Government respondents indicated the need for accuracy did not limit the expansion of parametric estimating techniques, while 37 percent indicated the need for accuracy did limit the expansion. Forty-two percent were neutral on this item. Of Non-PCEI Government respondents, only 26 to 53 percent felt parametric techniques were as accurate as traditional cost build up approaches with the higher percentage agreement during the concept/development phase of a program. Like the PCEI Government and Non-PCEI Industry groups, the percentage agreement dropped when looking at the benefits of accuracy from the six different types of parametric estimates. However, the agreement percentages were much lower than the other groups.

A comparison of the mean scores for the perceptions of accuracy for the acquisition groups is shown in Figure 3. The results show that PCEI Industry has the highest belief in the accuracy of parametrics, Non-PCEI Government the lowest, and the other two groups nearly the same halfway between. Some possible reasons for the highest and lowest perceptions of accuracy include knowledge, or lack of knowledge, of the effort devoted to developing the parametric technique and therefore its statistical predictive accuracy. Perhaps the low government perception is due to a lack of knowledge on

ACCURACY PERCEPTIONS
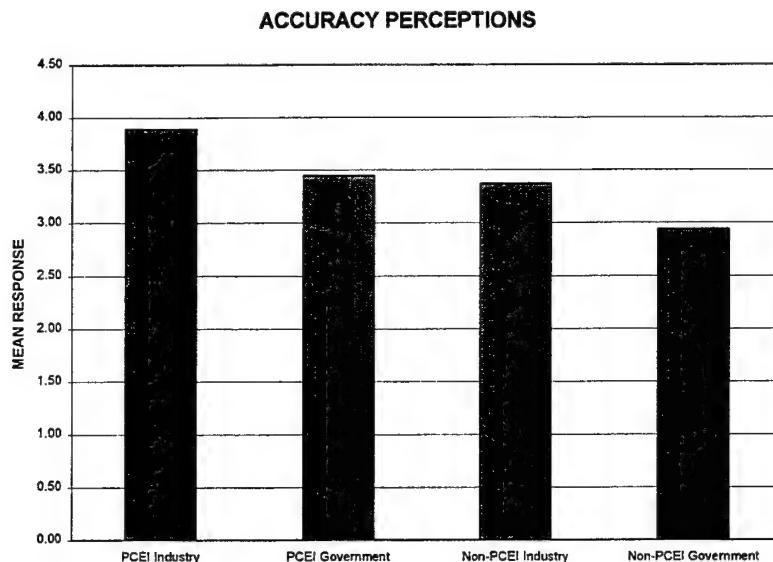
Figure 3. Perceptions of Accuracy

statistical predictive techniques in general. The difference in accuracy perceptions is significant but somewhat incomplete since it addresses parametrics in general without regard to type of parametric application under consideration. Accuracy with regard to type of parametric application is addressed in the discussion of investigative question five.

What may be more important than the perceptions of accuracy is the impact these perceptions have on customer acceptance. The two are likely closely related.

Investigative Question Four: How useful is parametric estimating to government contracting as influenced by phase of the acquisition cycle, perceived accuracy, and information availability? The intent of investigative question four is to evaluate if parametric techniques are considered useful. Usefulness is defined in terms of flexibility during certain phases of the acquisition cycle and contract types, and whether cost

information availability is a determinant. The following survey items were used to determine the usefulness of parametric estimating techniques:

S1Q5: The use of parametric estimating techniques should be expanded in DoD contracting.

S2Q1: Parametric estimating should only be used on cost type contracts.

S2Q3: Parametric estimating is more appropriately used during the concept/ development phase of a program.

S2Q6: If sufficient cost information is available, parametrics should not be used.

S2Q7: Contract type is a consideration for when parametrics should be used.

S2Q8: Parametrics should only be used to prepare initial budgetary or rough estimates.

S2Q13: Parametric estimating is inappropriate for use on follow-on production.

Table 6 provides the results for these questions.

All items were designed to be answered in the opposite direction except S1Q5. The overall mean scores for each of the four acquisition groups reflect a recoding of the data for the opposite direction items.

For S1Q5, over 90 percent of both PCEI acquisition groups and Non-PCEI Industry responded that the use of parametric techniques should be expanded, while Non PCEI-Government indicated only 37 percent agreement with this item. S2Q1 and S2Q7 deal with considerations concerning the type of contract. For S2Q1, no group strongly supported agreement with limiting the use of parametric estimating to cost type contracts. This may be somewhat surprising until you consider CER's are a type of parametric estimate. For S2Q7, the highest support for contract type being a consideration for

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Table 6. Responses to Questionnaire Items for Investigative Question Four

Item	n	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree	Mean
PCEI -Industry							**4.01**
S1 Q5	34	0.000	0.000	0.029	0.471	0.500	4.47
S2 Q1	34	0.441	0.412	0.088	0.059	0.000	1.76
S2 Q3	34	0.147	0.294	0.353	0.147	0.059	2.68
S2 Q6	34	0.324	0.471	0.176	0.029	0.000	1.91
S2 Q7	34	0.118	0.529	0.294	0.059	0.000	2.29
S2 Q8	34	0.441	0.471	0.029	0.029	0.029	1.74
S2 Q13	34	0.353	0.500	0.000	0.059	0.088	2.03
PCEI - Govt							**4.08**
S1 Q5	22	0.000	0.000	0.091	0.500	0.409	4.32
S2 Q1	22	0.545	0.364	0.091	0.000	0.000	1.50
S2 Q3	22	.0136	0.591	0.136	0.091	0.045	2.41
S2 Q6	22	0.136	0.591	0.227	0.045	0.000	2.18
S2 Q7	22	0.227	0.455	0.318	0.000	0.000	2.09
S2 Q8	22	0.409	0.455	0.136	0.000	0.000	1.77
S2 Q13	22	0.500	0.364	0.091	0.045	0.000	1.82
Non PCEI - Industry							**3.68**
S1 Q5	10	0.000	0.000	0.000	0.556	0.444	4.44
S2 Q1	10	0.300	0.200	0.100	0.400	0.000	2.60
S2 Q3	10	0.000	0.400	0.300	0.300	0.000	2.90
S2 Q6	10	0.300	0.200	0.300	0.200	0.000	2.40
S2 Q7	10	0.200	0.000	0.600	0.100	0.100	2.90
S2 Q8	10	0.300	0.500	0.200	0.000	0.000	1.90
S2 Q13	10	0.300	0.400	0.300	0.000	0.000	2.00
Non PCEI - Govt							**3.18**
S1 Q5	19	0.000	0.053	0.579	0.263	0.105	3.42
S2 Q1	19	0.053	0.632	0.263	0.053	0.000	2.32
S2 Q3	19	0.000	0.263	0.368	0.211	0.158	3.26
S2 Q6	19	0.000	0.316	0.368	0.263	0.053	3.05
S2 Q7	19	0.000	0.368	0.211	0.421	0.000	3.05
S2 Q8	19	0.000	0.421	0.474	0.053	0.053	2.74
S2 Q13	19	0.000	0.421	0.421	0.158	0.000	2.74

when parametrics should be used came from the Non-PCEI Government group but was only 42 percent in favor of that proposition. The other groups range from 0 to 20 percent. Again the impact of CER's being a type of parametric estimate could be significant.

Items S2Q3, S2Q8, and S2Q13 concern acquisition phase. Results on S2Q3, parametrics are more appropriate during the concept development phase, are mixed. PCEI Industry disagreed with that item 44 percent of the time, PCEI Government 73 percent of the time, Non-PCEI Industry 40 percent, and Non-PCEI Government 26 percent. Results for S2Q8 and S2Q13 provide a more discernible pattern. Except for Non-PCEI Government, there is 70 to 90 percent disagreement with limiting the use of parametrics to early phase estimates and not using it in production situations. Non-PCEI Government only had 42 percent disagreement with these limitations.

Item S2Q6 concerns whether information availability should eliminate the use parametrics. The PCEI Industry and Government groups had 80 and 73 percent disagreement with that premise, respectively, while the non-PCEI groups had 50 and 32 percent disagreement with that premise.

Overall utility is defined as a combination all seven of the items just discussed, each addressing some aspect of perceived utility such as use during any acquisition phase or contract type, and desire to expand the use of parametrics (reference Chapter III of this thesis). A mean response is developed for each of the seven items. The overall perceived utility measure is therefore established as the mean of the seven mean responses to the seven items just discussed. A comparison of the mean scores for the overall utility, or usefulness of parametrics is shown in Figure 4.

This measure of utility is more a measure of flexibility becasue the items that

compose it question whether parametrics should be use in any situation. The results

Utility of Parametric Estimating
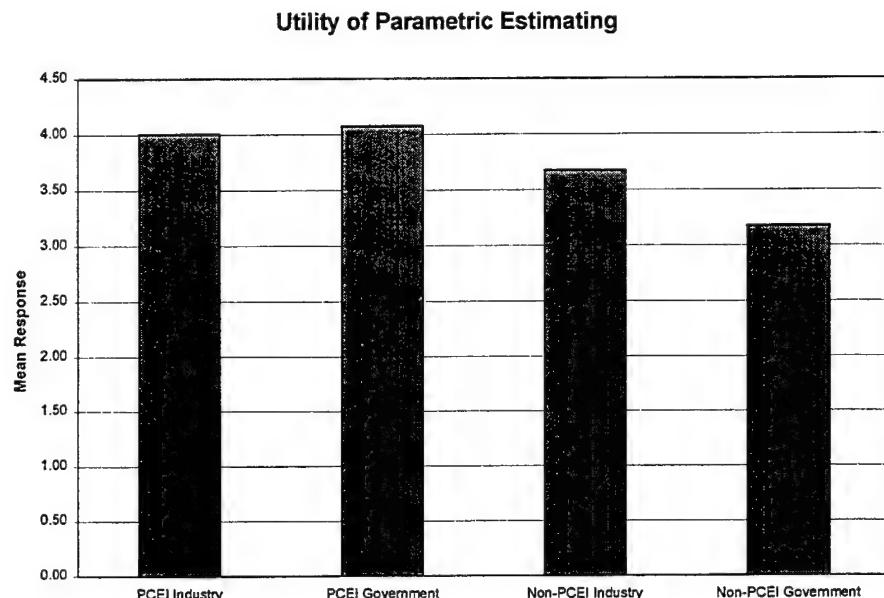
Figure 4. Utility of Parametric Estimating

show that PCEI Industry and Government have the highest belief in the utility/flexibility

of parametrics, Non-PCEI Government the lowest with Non-PCEI Industry splitting that

difference.

Investigative Question Five: Is there a difference in the perceived accuracy and

usefulness of the six types of parametric applications? The intent of investigative

question five is to evaluate the perceptions of accuracy and utility of the different types of

parametric applications across the different acquisition groups. Section 3 of the

questionnaire was used to evaluate differences in perceptions. The six applications

previously identified were: 1) CERs that are cost-to-cost, 2) CERs that are cost-to-non-

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cost, 3) commercial models that estimate the entire cost of a proposal, 4) commercial models that estimate only significant portions of a proposal, 5) in-house models that estimate only significant portions of a proposal, and 6) in-house models that estimate the entire cost of a proposal. Question 5 for each application, provide benefit in accuracy, was used to evaluate perceptions of accuracy for each application. Questions 1 through 4 and 6 for each application, were used to evaluate the usefulness or utility. These questions are: easy to develop (or learn), easy to use, frequently used, provide benefit in efficiency, and should be used at any phase of the acquisition. Table 7 provides the results for the accuracy application questions.

At least 60 percent of the PCEI Industry respondents indicated that parametric estimating techniques provide benefits in accuracy regardless of the application. This view is generally different from the other three acquisition groups. For the other acquisition groups, perceptions of accuracy were lower and there was generally a drop-off in perceived accuracy after the two CER categories. The exception, Non-PCEI Industry, had a 75 percent agreement that cost-to-cost CERs provide a benefit in accuracy, but dropped off to 50 percent for cost-to-non-cost CERs. Non-PCEI Industry also indicated a 56 percent agreement with the accuracy benefit of commercial models used to estimate the entire cost of a proposal, but less than 40 percent agreement on the other parametric types. The lower agreement level and drop-off pattern are readily discernible when looking at the two government groups. PCEI Government respondents provided only 55 percent agreement with the accuracy benefit of cost-to-cost CERs, 45 percent agreement with cost-to-non-cost CERS, falling off to 17 to 31 percent for the other parametric

applications. A majority of the PCEI government group provided neutral responses

concerning accuracy benefits obtained from the other four applications. The Non-PCEI

Table 7. Responses to Questionnaire Items for Investigative Question Five

Item	n	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree	Mean
PCEI Industry							
CERS Cost to Cost	31	0.000	0.129	0.194	0.516	0.161	3.71
CERS Cost to NonCost	32	0.000	0.094	0.250	0.469	0.188	3.75
Commercial Models - entire	33	0.030	0.030	0.333	0.455	0.152	3.67
Commercial Models - portion	30	0.000	0.033	0.233	0.533	0.200	3.90
In-house Models – portion	33	0.000	0.030	0.333	0.485	0.152	3.76
In-house Models – entire	32	0.000	0.031	0.375	0.406	0.188	3.75
PCEI Government							
CERS Cost to Cost	18	0.000	0.056	0.389	0.444	0.111	3.71
CERS Cost to NonCost	18	0.056	0.056	0.444	0.389	0.056	3.41
Commercial Models - entire	17	0.000	0.176	0.647	0.118	0.059	3.13
Commercial Models - portion	17	0.000	0.118	0.647	0.176	0.059	3.25
In-house Models - portion	16	0.000	0.125	0.563	0.250	0.063	3.33
In-house Models - entire	16	0.000	0.063	0.688	0.188	0.063	3.33
Non-PCEI Industry							
CERS Cost to Cost	8	0.000	0.125	0.125	0.500	0.250	3.88
CERS Cost to NonCost	8	0.000	0.500	0.000	0.375	0.125	3.13
Commercial Models - entire	9	0.000	0.111	0.333	0.556	0.000	3.44
Commercial Models - portion	8	0.000	0.125	0.625	0.250	0.000	3.13
In-house Models - portion	9	0.000	0.111	0.556	0.333	0.000	3.22
In-house Models - entire	8	0.000	0.375	0.250	0.375	0.000	3.00
Non-PCEI Government							
CERS Cost to Cost	19	0.000	0.211	0.368	0.316	0.105	3.32
CERS Cost to NonCost	19	0.000	0.158	0.526	0.263	0.053	3.21
Commercial Models - entire	19	0.158	0.158	0.579	0.105	0.000	2.63
Commercial Models - portion	19	0.053	0.368	0.474	0.105	0.000	2.63
In-house Models - portion	19	0.053	0.263	0.579	0.105	0.000	2.74
In-house Models - entire	19	0.053	0.368	0.474	0.105	0.000	2.63

Government responses display a substantially lower level with agreement of only 11

percent agreeing with accuracy benefit of the four types of applications other than CERs.

The associated histogram of the means scores for the perceptions of accuracy by

parametric application is shown in figure 5. For the PCEI Industry group, there is a
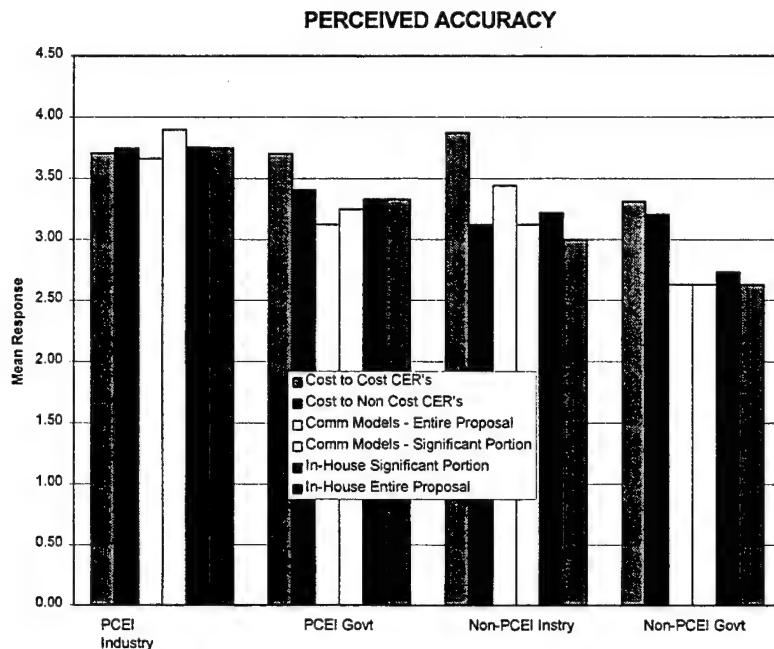
Figure 5. Perceived Accuracy by Parametric Application

uniform perception of accuracy among the different parametric applications. This uniform perception of accuracy does not exist with the other acquisition groups. The other groups tend to show a reduction in perceived accuracy as you move away from simple CERS to more complex parametric applications such as commercial and in-house models. The reduction in perceived accuracy of CERs and models is most noticeable for the Non-PCEI Government group.

Overall, the data suggests that PCEI Industry group sees very little difference in accuracy between the six types of parametric applications, whereas, the other three groups perceive CERs, particularly cost-to-cost, to be more accurate than the other types of parametric applications. The most noticeable difference in perception is from the Non-PCEI Government group.

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Investigative question five also addresses differences in perceived utility between the different parametric applications. Data from Section 3 of the survey was used to evaluate utility in five components: ease to develop, ease to use, frequency of use, benefit in efficiency, and can be used at any acquisition phase. Since commercial models are already developed, the item was changed to *ease to learn* on the two commercial

Table 8. Responses to Questionnaire Items for Investigative Question Five

Summary of Mean Responses for Different Application Types					
Ease to Develop	Ease to Use	Frequently Used	Efficiency Benefit	Used Anytime	Average (Utility)
Cost-to-Cost CER's					
PCEI-Industry — 3.74	4.28	3.81	4.29	3.81	3.99
PCEI-Government — 3.59	3.94	3.59	4.18	3.76	3.81
Non-PCEI -Industry — 4.00	4.38	4.00	4.25	3.75	4.08
Non-PCEI -Government — 3.58	3.89	3.95	3.79	3.47	3.74
Cost-to-Non-Cost CER's					
PCEI-Industry — 3.23	4.06	3.55	4.10	3.87	3.76
PCEI-Government — 2.71	3.41	3.06	3.65	3.47	3.26
Non-PCEI -Industry — 3.75	4.25	3.88	4.13	3.63	3.93
Non-PCEI -Government — 3.26	3.79	3.74	3.74	3.21	3.55
Commercial Models for Entire Proposals					
PCEI-Industry — 2.75	2.84	3.09	3.69	3.72	3.22
PCEI-Government — 2.69	2.94	2.50	3.44	3.25	2.96
Non-PCEI -Industry — 2.67	3.00	3.00	3.67	3.33	3.13
Non-PCEI -Government — 2.37	2.53	2.37	3.32	2.68	2.65
Commercial Models for Portions of a Proposal					
PCEI-Industry — 2.97	3.23	3.43	4.03	3.83	3.50
PCEI-Government — 3.00	3.13	3.06	3.69	3.44	3.26
Non-PCEI -Industry — 2.63	3.25	3.13	3.25	3.13	3.08
Non-PCEI -Government — 2.47	2.58	2.95	3.37	2.68	2.81
In-House Models for Portions of a Proposals					
PCEI-Industry — 2.00	3.03	3.13	3.81	3.47	3.09
PCEI-Government — 2.47	3.00	2.93	3.73	3.33	3.09
Non-PCEI -Industry — 3.22	3.22	2.78	3.56	2.89	3.13
Non-PCEI -Government — 2.84	2.79	3.00	3.42	2.84	2.98
In-House Models for Entire Proposals					
PCEI-Industry — 1.74	2.61	2.58	3.90	3.61	2.89
PCEI-Government — 2.60	2.93	3.00	3.47	3.27	3.05
Non-PCEI –Industry — 2.38	3.00	2.63	3.50	3.25	2.95
Non-PCEI –Government — 2.63	2.63	2.53	3.26	2.74	2.76

model applications. The mean response for the five components develops a composite

utility measure. Mean responses for each acquisition group and each type application

were calculated along with an overall utility response. Table 8 provides the results for the

utility application questions.

The associated histogram of the means scores for the perceptions of overall utility

by parametric application is shown in figure 6.

**Utility
by Response Grouping**
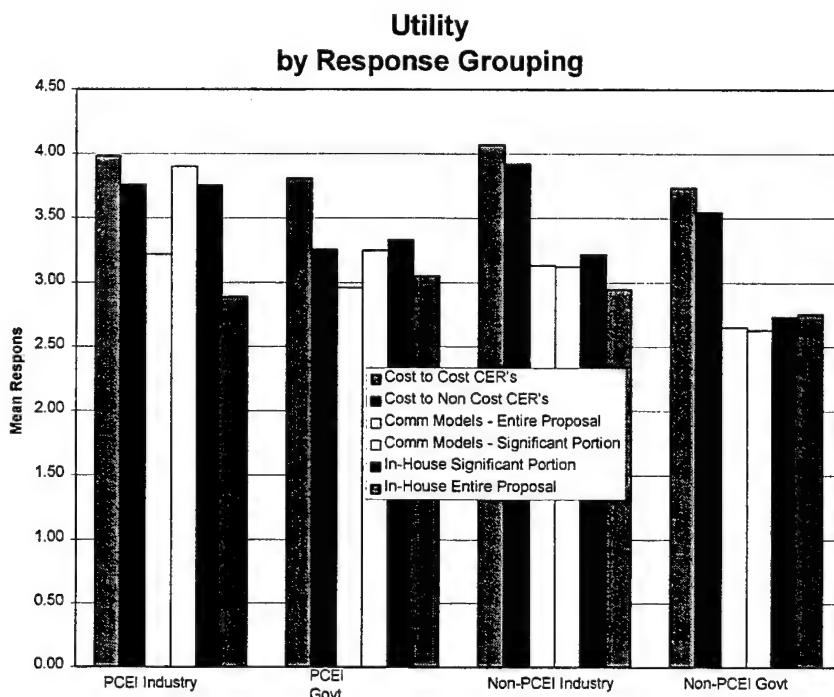
Figure 6. Perceived Utility by Parametric Application

The general pattern is similar to that of the accuracy histogram. There is a reduction

in the perception of utility for commercial and in-house parametric models as compared

to CER's. However, unlike accuracy, there is also a drop-off in PCEI Industry's

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perception of utility for models that estimate the entire cost of a proposal. This drop-off

pattern is more pronounced for the utility construct than accuracy. The reduction in

perceived utility between CERs and models is most noticeable for Non-PCEI

Government. It is also noteworthy that the Non-PCEI Government perception of utility

of CER's is comparable with the other acquisition groups. It is also observable that the

Non-PCEI Government perception of utility of models is somewhat lower than the other

acquisition groups. The Non-PCEI Industry drop-off is also very noticeable.

As previously discussed, the utility construct is composed of five different items. The

histograms for the mean responses of each of the utility items are shown in figures 7

through 11.
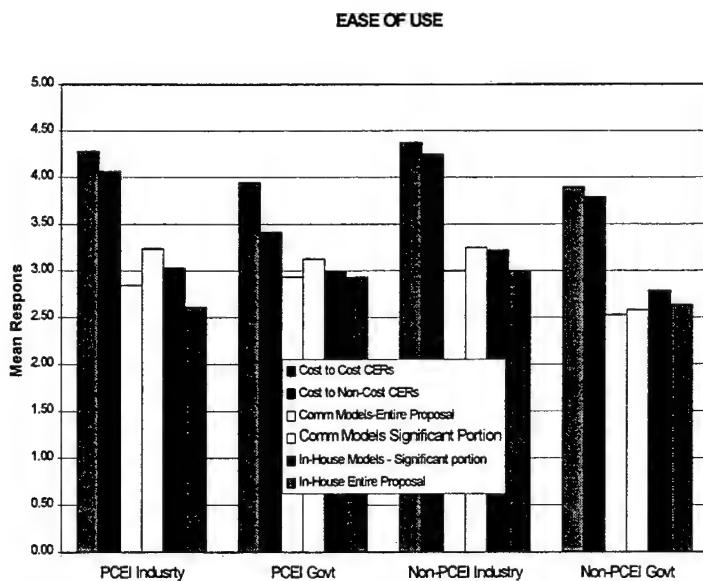
EASE OF USE



Figure 7. Perceived Ease of Use by Parametric Application

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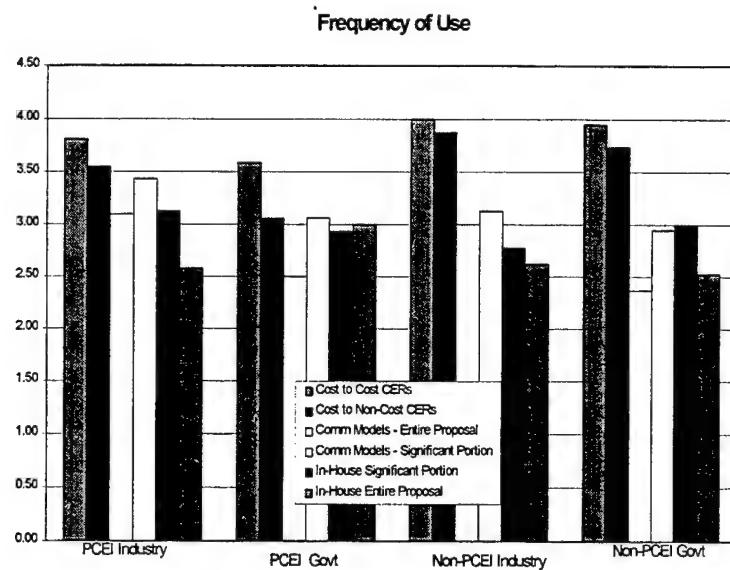
Figure 8. Perceived Frequency of Use by Parametric Application
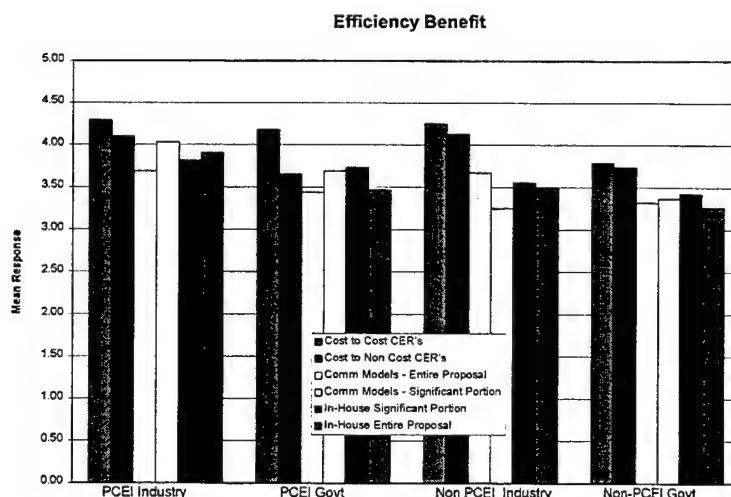
Figure 9. Perceived Efficiency Benefit by Parametric Application

64

Use During Any Acqusition Phase
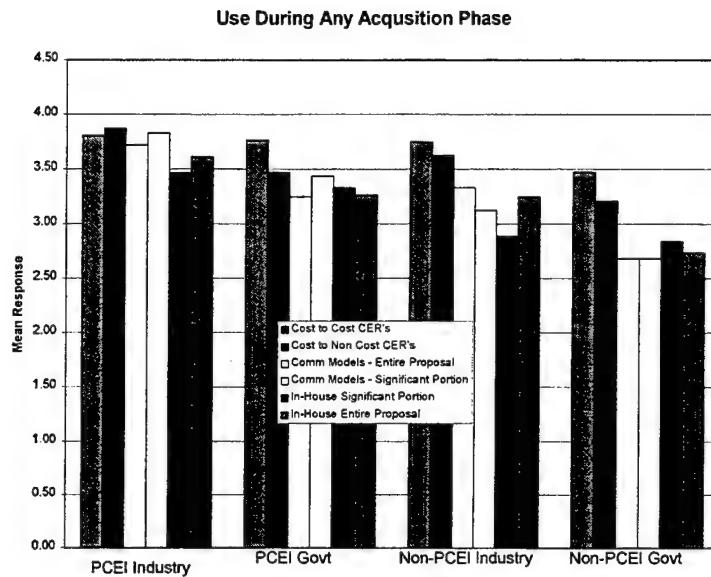
Figure 10. Perceived Use During Any Acquisition Phase by Parametric Application

Ease to Develop/Learn
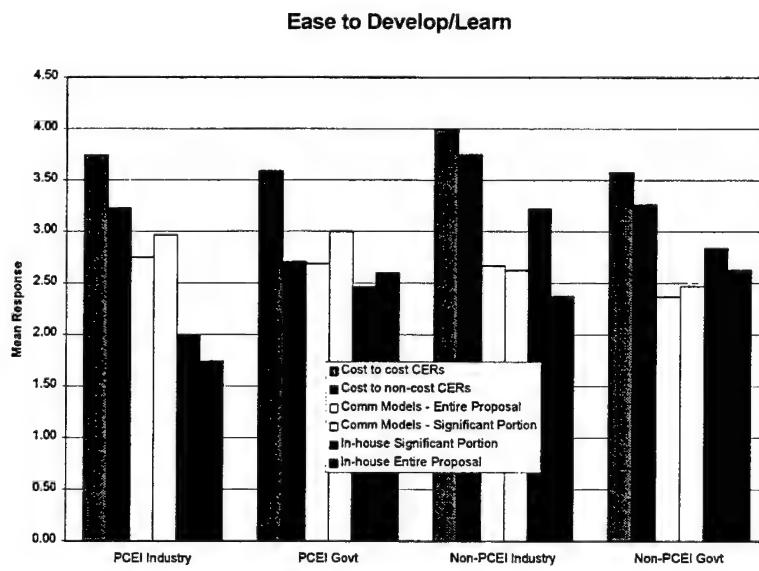
Figure 11. Ease to Develop/Learn

The histograms for the five items follow a similar pattern as the composite utility

measure - the mean response drop-off from CERs to parametric models. This drop-off is

most pronounced for Non-PCEI Government in nearly every case. The drop-off is noticeable for Non-PCEI Industry in nearly every case. PCEI Industry had a drop-off in ease of use, frequency of use, and ease to develop/learn, but little if any drop-off in efficiency benefit and use during any acquisition phase. PCEI Government had a drop-off from the cost-to-cost CER's only. Just like accuracy, PCEI Government tended to view cost-to-non-cost CER's on a similar level with models.

The data indicates all groups have some variance in their perceived utility of parametrics applications. The PCEI Industry group sees a decrease in the utility of parametrics when using commercial or in-house models to estimate entire proposals. However, if estimating only a portion of the proposal, these models are perceived to be as useful as CERs. The other three acquisition groups perceive a decrease in the usefulness of commercial and in-house models when compared with CERs, though sometimes only cost-to-cost CERs.

V. Conclusions and Recommendations

Overview

The previous chapter presented and discussed the results of our research study. This chapter concludes the discussion by providing possible ramifications and larger implications of the data evaluated against each research question. Explanatory information is discussed with regard to each investigative question presented in Chapter III. The five research questions are:

1. Has the use of parametric estimating increased and is more effort needed to expand its implementation?

2. What are some of the perceived barriers to implementation?

3. Do different acquisition groups have different perceptions on the accuracy of parametrics?

4. How useful is parametric estimating to government contracting as influenced by phase of the acquisition cycle, contract type, and information availability?

5. Is there a difference in the perceived accuracy and usefulness of the six types of parametric applications?

Summary Findings, Management Implications and Recommendations for Research Question One

Has the use of parametric estimating increased and is more effort needed to increase its use?

Overall, all acquisition groups perceived an increase in the use of parametric estimating, and all groups, except Non-PCEI Government felt more effort was needed to

expand the use of parametrics. The responses were only slightly above neutral (neither agree or disagree) suggesting that parametric expansion may not have increased significantly or as much as desired.

This information provides two management implications. First, we question why is there not a strong endorsement that the use of parametric estimating has increased. There are many success stories being shared but apparently, not many real uses in contracting situations. Ways need to be found to bridge that gap. The second implication is to determine the cause for why Non-PCEI Government people do not share the same level of endorsement of the proposition that more effort is needed to expand its use. One possible answer is that Non-PCEI Government people may not be party to the success events advocated by the PCEI and therefore, cannot justify expending additional effort in expanding its use. This is evidenced by the first management implication.

Recommendations. The PCEI needs to share successes with Non-PCEI government people to gain greater endorsement from them for applying more effort to expansion of parametric applications.

Summary Findings, Management Implications and Recommendations for Research Question Two

What are some of the perceived barriers to implementation?

Data, training, and model development were ranked high as barriers by all acquisition groups. TINA issues and lack of government support were ranked high by Non-PCEI Industry. Non-PCEI Government ranked utility and accuracy concerns highly.

The most significant management implication concerns data. The retrieval and organization of historical data is a precursor to any parametric expansion effort. The investment to perform that task should be placed as a higher priority than it has been in the past. The President of Lockheed Martin Tactical Aircraft Systems has stated parametric "models must be supported by current databases, and it is not an easy endeavor to develop and maintain these databases" (Hancock, 1996:2). This reflects the real concern a contractor encounters when trying to develop cost-to-non-cost CERs and in-house models.

Some insight on perceived barriers was provided from the March 1998 parametric conference. Mr. Joe Lewis of Boeing, a keynote speaker at the conference, stated data is the major obstacle to overcome in expanding the use of parametric estimating. He estimated that nearly fifteen man-years had been invested in reviewing and correlating the historical database information for Boeing's parametric effort (Lewis, 1998). GE has invested several million in the development of its COMPEAT model with data retrieval a large part of that investment.

During the 1998 conference, a question was asked why old data is important. In response, it was stated both old data and new data are important. Old data helps to establish the impact of technological advancements by looking at trends and what happens to cost when efforts are made to advance technology. New data is significant because it is easier to correlate, thereby providing a current point of projection (Parametric Cost Estimating Joint Industry/Government Initiative Workshop, 1998). Boeing believes you can not proceed on parametrics until you know where you have

been. In contracting, it does not appear that most contractors acknowledge this and are ready to make the required investment.

During the 1998 conference, Mr. H. Apgar, MCR, stated that in his consulting role, mock audits are often run on contractor's attempts to establish parametric systems. The contractors are questioned about what historical data is available, or what plans exist to retrieve, organize and normalize data. The answer is invariably, none (Parametric Cost Estimating Joint Industry/Government Initiative Workshop, 1998). This condition is not supportive of institutionalizing parametric estimating. Data is needed not only to develop CERs but also to validate and calibrate commercial models. Without data, there is no expansion of parametric estimating.

Mr. Apgar was one of the founders of ISPA twenty years ago. He tells the story of how he expected it to take a few years to change the world. Twenty years have since passed, and it now appears the world is ready for change, but the data to change the world is not available. Expectations are unusually high when a quicker or better way of doing something is announced. Most people expect immediate results. Many companies expect two and three year paybacks on savings programs. It has been pointed out that the benefits to be derived from parametric estimating cannot be realized until the up-front cost to calibrate and validate the models has been invested and until the models are understood and accepted as a reliable predictor of cost (Allocation of Resources, 1996:8) This can only occur with good data.

Research directed to this end may help to improve parametric estimating. Model validation is not feasible until a contractor can retrieve, organize, and correlate its

historical data. The PCEI would do well to stress the importance of this concept.

Because of the volume and variety of data needed, it is a struggle to accumulate and

accurately manipulate required historical data to make models credible. If there is a

single reason why parametric estimates may take some time to implement, it is likely the

data issue. Estimates for how long it will take to institutionalize parametric estimating

vary from 2 to 15 years (Parametric Cost Estimating Joint Industry/Government Initiative

Workshop, 1998).

Another implication from the barriers information addresses the need for

government approval authorities to provide a firm mechanism for dealing with

subcontract cost or pricing data when using parametric estimating. This was the number

one concern for Non-PCEI Industry and it is a valid concern. In one specific case, an

industry executive stated that it is too time consuming to get subcontractor proposals for

each follow-on procurement. Parametric estimating was a more efficient way of

accomplishing this (Fowler, 1997). Many acknowledge that subcontract cost and pricing

data are the major impediments in reaching negotiated settlements. There are few if any

examples of buying offices accepting parametrically estimated subcontract cost in lieu of

subcontract cost and pricing data.

There is also a need, especially on the government side, to be aware of and prepare

for required training. The PCEI identified training as an important focus area from the

very beginning. Courses have been and are still being developed to provide general and

specialized knowledge in statistical mathematics and parametric model use (Working

Relationships, 1997:16). Commercial model vendors provide training on the use of their

models but it is generally acknowledged that it takes a lot of on-the-job use to gain expertise with most commercial models. Some contractors do or will have to provide specific training on applicable contractor models.

There is some uncertainty about what exactly should be taught for specific situations. A typical parametrician is certainly knowledgeable in graduate level statistics, but the average buyer/contracting officer is not going to be a parametrician. For buying offices, the problem may not be too pronounced. If a contractor is using CERs, the statistical knowledge is needed during its development, not during its use. Expanded use of simple CERs, should be business as usual. DCMC and DCAA personnel have a greater need for in-depth statistical knowledge as they need to ascertain the predicative accuracy of whatever parametric application is being proposed for use. The amount of statistical training needed at product divisions is more a function of how involved the product divisions want to be during the development of parametric applications. In most cases, that current involvement is low. That is not necessarily bad or unusual since CERs can be thought of as rates. Once the DCMC or DCAA recommends acceptance of the rates, the buying offices seldom challenge these recommendations. There is no reason why this change should be any different.

Training on use of specific parametric models is a different case. Most models are fairly complex and specific training needs must be identified on a case by case basis. The importance of training was greatly emphasized at the March 1998 conference.

Recommendations. General procedures need to be established for kinds of data that are needed, and for cost effective ways of retrieving and organizing data. Some

suggestions have proposed ideas such as bringing in retirees who have first hand knowledge of the historical data. In addition, a panel of working level contracting officers, price analyst, and reviewers should be convened to provide recommendations on how buying offices should address the apparent conflict that exists between FAR 15 requirements and parametric estimates as it relates to subcontract pricing. Concerning, training, the only real action suggested is for buying activities to be aware of any future receipts of parametrical model estimated proposals to allow sufficient lead-time to accomplish the necessary training.

Summary Findings, Management Implications and Recommendations for Research Question Three

Do different acquisition groups have different perceptions on the accuracy of parametrics?

PCEI Industry and Non-PCEI Government have vastly opposing perceptions on the accuracy of parametric estimates, with the other two groups about halfway between the high/low extremes. Some suspect the problem stems from lack of involvement. Approximately 250 people attended the March 1998 parametric conference, roughly half government and half industry. Far less than twenty were from buying activities. A belief exists that buying activities are reluctant to accept parametric estimates. DCMC and DCAA have been involved in the PCEI for nearly four years while the applications were being developed. Buying activity involvement has been slim to none. The PCEI considers the contractor to be responsible for integrating the buying activity downstream

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once the parametric applications are defined. There is no consensus on the strengths or deficiencies associated with lack of early buying activity involvement, only concern over the lack of acceptance.

The magnitude of the problem concerning customer acceptance is a function of the type of application used. The greater the complexity of the parametric application, the more likely customer acceptance will be a problem. Do buying functions need to be involved in establishing procedures for the proper use of parametric models? How long will it take to be able to correctly use the models? How much involvement will the buying office need in the process of model validation and calibration? This is where confidence in the parametric estimate is gained. The buying activity needs to become involved sooner if the applications used are more complex because the application defines the complexity of the knowledge necessary to have confidence in the quality of the bidding methodology.

Addressing the question of accuracy is more a question of addressing the possible inverse relationship between accuracy and efficiency of preparation. The initiative's goals clearly include using parametrics to develop estimates at a lower cost with similar accuracy. Mr. Jim Collins, Co-Chairman of the PCEI, stated the benefits of parametric cost estimating techniques include reduction in proposal preparation cost, reduction in proposal cycle time, and more reliable estimates. Collins also states that without demonstrated benefits and reliable estimates, there will be no reason for change and parametric cost estimating processes will not be adopted (Collins, 1996:8). The Manager of Military Proposals at GE Aircraft Company stated:

There are no required or suggested levels of precision for any cost estimating technique as previously referenced. The use of all cost estimating systems requires that it form an acceptable basis for negotiations. The contractors use of a cost model should not be subject to a different set of rules or guidelines than their other cost estimating routines. The level of precision would then be reasonable to apply at a total proposal price since this is the basis for negotiation. (Brandstetter, 1996:6)

Another industry executive stated precision is a matter of judgement, higher levels of precision are needed on fixed priced contracts (Calibration/Validation, 1996:11). The mention of contract type and *precision* of estimate is interesting. In her January 1997 letter, the Principal Deputy Assistant Secretary (Acquisition & Management) stated parametrics "...can produce contract price estimates of equal or better reliability that traditional bottom-ups estimates" (Druyun, 1997:1). The basis of these equal accuracy statements contradicts the status quo and any empirical or other evidence presented in the literature.

The Parametric Cost Estimating Initiative does not ignore this. The PCEI Steering Committee stated the degree of accuracy required should be as accurate as the current proposal method in predicting cost. However, the "principal goal of the initiative is to lower estimating and oversight costs...to mandate a specific [accuracy] percentage would be counterproductive. One would hope be able to predict cost within ±10% for established programs but accuracy within ±25% may be all that is achievable on a development contract" (Collins & Eck, 1997a). The acceptability of those target percentages is uncertain. Will contracting officers subscribe to estimating techniques with ±10% accuracy on established programs? Several questions concerning accuracy

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were presented in the Parametric Cost Estimating Initiative newsletters. How will the contractor demonstrate the model is reasonably accurate? What are the criteria for measuring accuracy? What is a reasonable variance percentage? The response was the contractor must have a procedure to demonstrate accuracy to provide credible estimates. Accuracy must be similiar to existing methods (Calibration/Validation, 1996:11 - 12).

The accuracy question is a tough one to address and the PCEI has left many questions unanswered in dealing with it. There has yet to be a detailed documented discussion of accuracy topics such as sources of inaccuracy and quantifying inaccuracy for risk analysis purposes. The Parametric Cost Estimating Newsletter does contain numerous examples of calibration efforts at different sites. Calibration is the process of adjusting a commercially developed model from industry averages to customized local experience and performance. However, accuracy must contend with the reality of substantial non-recurring start-up cost. Given a fixed level of information, time, and resources, how can parametrically oriented estimating approaches improve upon what is done now? Little evidence exists that adequately addresses the accuracy efficiency trade-off.

For management, this implies without customer belief that the estimating technique used is accurate, it will not be accepted and used. The discussion of accuracy perceptions becomes clearer when different parametric applications are considered in investigative question five.

Summary Findings, Management Implications and Recommendations for Research Question Four

How useful is parametric estimating to government contracting as influenced by phase of acquisition cycle, contract type, and information availability?

Both the PCEI Industry and Government groups responded more positively to the use of parametric applications in any situation as compared with the Non-PCEI Government group. The Non-PCEI Government group did not support limiting parametrics to cost type contracts, though this answer will be later contradicted by findings in investigative question five.

This information implies that those disposed to prepare and negotiate proposals, both Non-PCEI Government and Industry, are somewhat unsure about using parametrics in situations where it may not have been previously used. While traditional views may advocate that there are situational limitations to the use of parametrics, the PCEI, both government and industry, believe in the unlimited use of parametrics in all situations. It appears that more demonstration of the flexibility and benefits of using specific techniques will have to be sold to the primary users.

One of the senior service acquisition officials provided another perspective of buying activity attitudes at the March conference. He stated it is unquestionable the acquisition side of the house at the higher management levels categorically supports this initiative (Parametric Cost Estimating Joint Industry/Government Initiative Workshop, 1998). All the service executives emphasized that more parametric estimation is necessary because DOD can no longer man to the levels necessary to do things the way

they have always been done. The major issue is credibility; "there is a distinction between something that is theoretically correct and something that is practically useful" (Rany, 1997). Discussions of parametric estimating utility, just like accuracy, are difficult, if not impossible. One must determine what type of parametric application is being discussed. These issues are addressed in investigative question five.

Summary Findings, Management Implications and Recommendations for Research Question Five

Is there a difference in the perceived accuracy and usefulness of the six types of parametric applications?

As parametrics moves from the simpler CERs to the more complex models, only PCEI Industry did not experience a drop-off in the perception of accuracy. The drop-off was more pronounced after cost-to-cost CERs and more pronounced for Non-PCEI Government. There was some degree of a drop-off in the perception of utility in all four acquisition groups. PCEI Industry, perceived noticably less over all utility from parametric models that estimate entire proposals. For both Non-PCEI groups, the overall dropoff in the perception of utility from CERs to any type model is distinct. PCEI Government saw utility drop off after cost-to-cost CERs.

The overall utility construct was composed of five items: ease to develop or learn, ease to use, frequency of use, benefit in efficiency, and can be used at any acquisition phase. When evaluating ease of use, frequency of use, and ease to develop or learn, the drop-off effect was noticeable and consistent across all groups. When looking at

efficiency benefit and use during any acquisition, the drop-off was less pronounced but did exist, more for Non-PCEI Government and less for PCEI Industry

For management, the differences between CERs and parametric models implies we may be using a common term for concepts and activities that are different in several significant aspects. This is significant for several reasons. First, it indicates that PCEI efforts to expand the use of CERs will be understood and supported because the providers and customers already believe in the benefits of this type of parametric approach. Conversely, PCEI efforts to expand the use of parametric models must demonstrate the models provide at least as much utility and accuracy as current methodologies. Discussing parametrics by the type of application is necessary because it provides a basis for activities required to expand the use of different types of applications.

The PCEI objectives and philosophies advocate a position that parametric applications can give it all at once, quick, cheap, and accurate. Is this a contradiction with the propositions stated in the accepted literature? Also, is this adverse to the opinions of other acquisition groups, particularly Non-PCEI government? If the entire context of parametric estimating is considered, it is possible, even probable, that certain parametric applications can give you quicker, faster, and better estimates in certain situations. Others will take longer, cost more, and be less accurate than traditional techniques. The Director of Defense Procurement's comments about parametrics being another tool could be right on the money so the question becomes when do we use what tool? (Spector, 1995:1). The worst thing we could do is to use a wrench to remove a splinter.

The general term parametric estimating is very broad. It is analogous to a farmer saying we are planting food seeds. Expanding the use of cost-to-cost CERs is very different from expanding the use of commercial models. Different from both are the problems of developing and expanding the use of in-house models. Separate requirements for each application should be provided for training, time and effort, limitations and barriers, and appropriate situations of use. Defining the issues associated with each of the six types allows a cost benefit analysis to be made about each of the specific types. This should improve management decision making concerning the appropriate use of parametric applications.

The concept of different parametric applications is very important when judging the worth of the PCEI. It is worth taking a look at the accomplishments of the PCEI from the perspective of the different types of parametric applications. Information about the accomplishments of PCEI is derived from two sources, the Parametric Cost Estimating Initiative newsletters between April 1996 and December 1997 and the 3-4 March 1998 Parametric Cost Estimating Joint Industry/Government Initiative workshop. The real worth of the PCEI is revealed from their accomplishments.

Lockheed Martin Tactical Aircraft System's (LMTAS) efforts to estimate engineering design cost based on hours per engineering drawing change is frequently mentioned in the newsletters. Since this is a cost-to-non-cost CER, the data had to come from two different sources. Correlating and validating the data historical database sources was difficult. Boeing Information & Communications System's (BI&CS) effort involved establishing a process for developing, applying and validating CERs. This

approach involved a titanic effort to analyze historical data from 38 databases, 150

contracts spanning 20 years, and involved numerous programs and millions of hours.

The Boeing effort may have begun as early as 1989, prior to the PCEI, with a main goal

of taking most of the judgment out of their proposal estimates. Boeing claims the result

could achieve more than a "50% reduction in proposal flowtimes" (Executive Summary,

1997:11). There are several other *Lab Site* accomplishments like those at LMTAS and

Boeing. In all the cases, the efforts involve going back and establishing more cost-to-cost

and cost-to-non-cost CERs.

CERs are a simpler parametric technique to understand. The contractors who have

made the sizeable investment to take this retrospective look at their own cost history

admit how difficult and expensive it is to get the required data and find a way to correlate

the cost data to the activity accomplished and the cost drivers and products that

influenced the events. Although costly, they expect the activity to be a good investment.

Some other contractors have yet to commit to this course and fail to see the value. A

Boeing executive stated this CER development activity was a good place to start. Start

small and at least know what you've done and establish a baseline for it (Parametric Cost

Estimating Joint Industry/Government Initiative Workshop, 1998).

The government has never discouraged the use of CERs. The CERs were not used

because they were not available - especially cost-to-non-cost CER's. The use of CERs

was not really thought of as a parametric technique, yet clearly it is. When based on

auditable historical data, these parametric applications do give it all - quicker, faster,

better, provided the inputs of those CERs can be accurately estimated. If the CER is

hours per drawing; if historical data has been properly used to develop the CER; and if the number of drawings can be accurately estimated for the current project, there is probably no better way to provide an estimate for drawing labor hours. Accuracy is a function of the accuracy of the CER and, equally important, the estimated input to the CER. CERs remove some of the judgement from estimating. The government does not prefer the use of purely judgement estimates. Judgement estimates usually cause negotiation problems. One LMTAS executive stated they are formalizing what they have always done or what they should have been doing (Parametric Cost Estimating Joint Industry/Government Initiative Workshop, 1998).

Because of CERs, it is easy to understand why the PCEI can claim achievements of quicker, faster, and more accurate. The expanded use of CERs would formalize and encourage quantitative traceable estimates. Once the CERs are properly developed, all that is needed is the task and the magnitude of the task to develop the input to the CER. During the conceptualization and development phases, these tasks and magnitudes are not known or cannot be quantified. Cost-to-non-cost CERs become more essential because the goal is to relate cost directly to the product.

The more complex parametric applications involve multiple CER parametric models. The inputs are no longer how many drawings or pages of output are expected because that information is not available. The inputs are more general and product oriented. The inputs can be as general as the expected weight, size, material, throughput, packaging, speed, design complexity, and many other higher and lower level product characteristics or performance specifications. The difference between the use of these

complex models and simple tasks and product oriented CERs is very significant. An unfamiliar user of the complex model will have no ability to relate the estimate to his/her common sense as the correlation between the estimate and the task gets lost in the black box nature of the parametric model. While that is a drawback, there is a significant upside - potential gains in accuracy and speed in certain situations.

During the Parametric Cost Estimating Joint Industry/Government Initiative, a great example of using a parametric model to estimate conceptual and preliminary design cost for advanced trans-atmospheric and orbital vehicles (Smith, 1998:2). The model is based on nearly thirty years of system level data provided to the Redstar database of the DOD Cost Analysis and Improvement Group. The model was tested by establishing concurrent estimates and making comparisons to the established PRICE and SEER commercial models. For unknown reasons, parametric modeling was not used when proceeding to the hardware development phase.

General Electric (GE) Aircraft Engines claims significant productivity gains from the development of their Cost Offering Method for Affordable Propulsion Engineering Acquisition and Test (COMPEAT) model on the Joint Strike Fighter program. The model was created by engineering and military proposal groups to make faster, more accurate, and less expensive cost estimates. COMPEAT$ has multiple uses including military engine development proposals, commercial engine studies, conceptual/ preliminary/detailed design studies, competitive analysis, should cost analysis, and target costing (Griffin and Stearns, 1997:9; Parametric Cost Estimating Joint Industry/ Government Initiative Workshop, 1998). Raytheon E-Systems provides another example

of contractor developed parametric models with their Production Cost Estimating Model & Bidding Tool. The products modeled are all near or advancing state of the art communications hardware.

There are other examples of parametric model development, but not nearly as many as the PCEI accomplishments in the area of simple CERs. Two main reasons exist for this. First, in both the NASA and GE situations, the use of these *in-house* models has limited applications. The models are intended to be used for estimating the cost of something new, complex and different. GE stated they did not intend to use COMPEAT very much in firm priced proposals (Griffin and Stearns, 1997). The NASA model was only used for conceptual and preliminary design studies.

The second reason for the fewer accomplishments on parametric models is time, cost, commitment, and payback concerns. These models involve most of the same activities required to develop the simple CERs, plus the additional activities to integrate those CERs into a comprehensive parametric model. There is a common thread between NASA spacecraft, new GE jet engines, and Raytheon E-System products. The connection is something new, very different, and unique; something for which there is not experience building; something for which there is not direct cost history. Each of the three companies/agencies mentioned also regularly develops new and different systems , at least often enough to justify the development of these parametric models. Without the PCEI, it is not likely these applications would exist or be as far along.

Even with the PCEI, the use of the models is regulated by the creators or the real stakeholders. GE is unlikely to use COMPEAT when other more quantifiable techniques

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are available. NASA contractors are unlikely to use NAFCOM when they clearly know their task. Why then is LMTAS using PRICE H to estimate F-16 after building over 3,700 aircraft? Why is Northrop Grumman testing the use of PRICE H to estimate radar system costs in their third production lot? A possible answer was obtained in a series of interviews from contractor and government personnel involved in one of these efforts.

In procurement involving aircraft follow-on production, a DOD contractor used a commercial model. The commercial model was not validated and calibrated in the traditional way using actual cost history. Instead, the contractor used recently negotiated cost for aircraft of a similar configuration and force fit the model to those negotiated values. This may have been due to the difficulty of obtaining and organizing actual cost history. This was an issue since parametrics estimating still require current cost or pricing data. Negotiated cost from previous efforts are not the most current cost or pricing data.

Management also imposed a goal to definitze the effort within three months of receipt of the contractor's proposal. Eight months later, the contractor and government were still several percent apart at the cost line. The effort started with a near 20 percent variance between government and contractor positions. On a mature program, where follow on buys have small configuration differences and those differences involve large dollar values, the estimating approach should provide a better baseline than a 20 percent variance. Previous use of these models on development and conceptual efforts seemed appropriate. The ±25 percent accuracy was understood and generally accepted. However, this kind of accuracy on mature programs causes some concern. The models

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must achieve at least as high a level of precision as traditional expectations. Both parties agree that calibration is the key issue to accuracy. Calibration quality is driven by the accuracy of the cost and technical data used. Once the data is audited for accuracy and the calibration techniques are approved, customer and contractor can be satisfied that the estimating tool is accurately baselined. Some of the government personnel feel this approach has promise, others are skeptical. One government analyst concurred that confidence in the accuracy of the model comes from how it was calibrated and stated it was not that difficult to use. There is some support for using parametric models for follow-on production efforts. It is believed that accuracy concerns can be properly addressed once an agreement on data used to calibrate is determined. Other government people feel this is not the right approach for follow-on production.

Ultimately, the reasons for using the parametric model were reduced proposal preparation costs and cycle timesavings. The contractor claims the parametric model approach will reduce the span time by approximately 50 percent while cutting proposal preparation costs by approximately 60 percent. Cycle time on a proposal includes time to negotiate issues. A common issue concerns today's push for higher productivity and improved quality assurance. The customer wants its share of those savings. The models have ways of accommodating these issues but do not make contractor and government agreement on quantifying the impacts of current and future changes any easier. These issues must still be negotiated which does take time. Eventually, the parties could end up using more traditional approaches to negotiate the effort.

There are local efforts underway to address the conflict between using parametric models on follow-on production and FAR 15 requirements for subcontract data. On this effort, the contractor provided required cost or pricing on subcontracts. The contractor believes that estimating subcontractor cost with historically indexed parametric models is a low risk for the government and the contractor as long as the product configuration remains the same or similar. However, since contractors are required by law to get current quotes and evaluate whether they are fair and reasonable, this can negate the cycle time reductions achieved by using the parametric process. Some possible solutions under consideration include: 1) periodic data and calibration updates similar to forward pricing rate agreements and designed to meet TINA requirements, 2) TINA waivers on subcontractor cost or pricing data, 3) regulatory change - parametric or other analysis to determine reasonable price from subcontractor, 4) definition change of cost or pricing data for parametric models, 5) TINA exemption for parametrics, and 6) leave contractor at risk of TINA non-compliance.

The encouragement of the use of CERs by the PCEI should have a positive effect on the proposal preparation and negotiation process,. The initiative should be commended for that effort. Conversely, the PCEI may be encouraging the use of complex parametric applications in situations where its use is suspect.

Recommendations. Be more specific about the type of parametric application under discussion.

Recommendations for Further Research

Future research in this area should focus on quantifying the impediments to the expanded use of parametrics. There are several areas where this study provides a basis to proceed:

1. Determine the main problems in gathering and organizing data and developing parametric models. Develop feasible solutions with the estimated cost of implementation.

2. Determine why Non-PCEI Government have such a low perception of the accuracy of parametric models. What should the PCEI attempt to do to increase the confidence of acquisition groups outside the initiative concerning the accuracy of parametric techniques?

3. Explore possible impacts of not using cost or pricing data, especially on subcontracts.

Ending Comments

The major findings of this study are summarized as follows. Except on the issue of CERs, Non-PCEI Government were consistently lower in their perception of parametrics. The use of the single term *parametric estimating* as an encompassing description for CERs and parametric models is improper because there is a difference in how CERs and parametric models are perceived. Several barriers to implementation still exist. Examples include data, model development, training, accuracy perceptions, and acquisition rules including subcontract pricing.

How extensively parametric estimating is ultimately adopted will be determined by whether its use makes sense to the office and people responsible for the procurement. Contracting officers, contract negotiators, and pricing specialist will need concrete reasons to adopt vastly different estimating methods over those that they are familiar with and make sense to them. Since the authority to determine a price is fair and reasonable is delegated to these lower levels, the use of a parametric estimating approach must appeal to the working level users. It must provide a confidence at least equal to conventional methods currently in use. If expanded parametrics use cannot do this, its future may be bleak beyond the current applications.

A summary of the Deputy SAF/AQ's comments at the March conference provide a fitting end to this thesis. General Anderson wants this done faster. Data capture, analysis, and maintenance is the key. Define terms clearly so we all clearly understand what we are saying. Traning for both sides, government and contractor, are also essential (Raney, 1998).

Appendix A: Questionnaire on Parametric Estimating

Read each statement and CIRCLE the number to the right that best indicates how strongly you agree or disagree with it	Strongly Disagree 1	Disagree 2	Neither Agree nor Disagree 3	Agree 4	Strongly Agree 5
SECTION 1 EXPANDED USE OF PARAMETRIC ESTIMATING					
1. The use of parametric estimating techniques has increased in the past 3 years.	1	2	3	4	5
2. The government and industry have been successful in expanding the use of parametric estimation.	1	2	3	4	5
3. More effort is needed by industry to expand the use of parametric estimating.	1	2	3	4	5
4. More effort is needed by the Government to expand the use parametric estimating.	1	2	3	4	5
5. The use of parametric estimating techniques should be expanded in DoD contracts.	1	2	3	4	5
6. Regulations have prevented full implementation of parametric estimating techniques.	1	2	3	4	5
7. Sufficient funds and time have been invested by industry to expand the use of parametric estimating.	1	2	3	4	5
8. Sufficient funds and time have been invested by the Government to expand the use of parametric estimating.	1	2	3	4	5
9. The need for accuracy limits expansion of parametric techniques.	1	2	3	4	5
10. The availability of data limits the expanded use of parametric techniques.	1	2	3	4	5
11. Customer acceptance limits the expanded use of parametric techniques.	1	2	3	4	5
SECTION 2 UTILITY (ACCURACY, ACQUISITION PHASE, CONTRACT TYPE) For this section, the term <u>Parametric Estimate</u> refers to <u>In-house or Commercial Models</u>, not simple CERS.					
1. Parametric estimating should only be used on cost type contracts.	1	2	3	4	5
2. If information is limited, parametric estimating techniques should be used.	1	2	3	4	5
3. Parametric estimating is more appropriately used during the concept/development phase of a program.	1	2	3	4	5
4. Parametric estimating techniques can be used to estimate change orders.	1	2	3	4	5
5. The amount of cost information available determines what method should be used.	1	2	3	4	5
6. If sufficient cost information is available, parametrics should not be used.	1	2	3	4	5
7. Contract type is a consideration for when parametrics should be used.	1	2	3	4	5
8. Parametrics should only be used to prepare initial budgetary or rough estimates.	1	2	3	4	5
9. The accuracy of establishing contract price is more important than the efficiency of establishing contract price.	1	2	3	4	5
10. Parametric estimates are as accurate as traditional cost build up approaches on concept/budgetary estimates.	1	2	3	4	5
11. Parametrics estimates are a accurate as traditional cost build up approaches on mature program estimates.	1	2	3	4	5
12. Parametric estimates are as accurate as traditional cost build up approaches in forecasting productions costs.	1	2	3	4	5
13. Parametric estimating is inappropriate for use on follow-on production.	1	2	3	4	5
14. Risk analysis is important in estimating.	1	2	3	4	5
15. Risk analysis is more important in parametric estimates than conventional estimates.	1	2	3	4	5

Please turn the page over to continue

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SECTION 3 PARAMETRIC APPLICATIONS

The statements below refer to six categories of parametric applications. Read each statement and FILL IN the number below that best indicates how strongly you agree or disagree with it.   Note: Commercial and In-house models are composed of multiple Cost-to-Cost and Non-Cost Cost Estimating Relationships (CERs).

	Neither			
Strongly Disagree	Disagree	Agree nor Disagree	Agree	Strongly Agree
1	2	3	4	5

CERs that are Cost to Cost
(Example: QA is 21% of production hours):
1.____Are easy to develop.
2.____Are easy to use.
3.____Are frequently used.
4.____Provide benefit in efficiency.
5.____Provide benefit in accuracy.
6.____Should be used at any phase of the acquisition cycle.

CERs that are Cost to Non-Cost
(Example: Hours per page):
1._____Are easy to develop.
2._____Are easy to use.
3._____Are frequently used.
4._____Provide benefit efficiency
5._____Provide benefit in accuracy.
6._____Should be used at any phase of the acquisition cycle.

Commercial Models that estimate the entire cost of
a proposal (Example: PRICE H)
1.____Are easy to LEARN.
2.____Are easy to use.
3.____Are frequently used.
4.____Provide benefit in efficiency.
5.____Provide benefit in accuracy.
6.____Should be used at any phase of the acquisition cycle.

Commercial Models that estimate only significant portions
of a proposal (Example: COCOMO, Software Hours):
1._____Are easy to LEARN.
2._____Are easy to use.
3._____Are frequently used.
4._____Provide benefit efficiency
5._____Provide benefit in accuracy.
6._____Should be used at any phase of the acquisition cycle.

In-house Models that estimate only significant portions
of a proposal:
1.____Are easy to develop.
2.____Are easy to use.
3.____Are frequently used.
4.____Provide benefit in efficiency.
5.____Provide benefit in accuracy.
6.____Should be used at any phase of the acquisition cycle.

In-house Models that estimate the entire cost of a
proposal:
1._____Are easy to develop.
2._____Are easy to use.
3._____Are frequently used.
4._____Provide benefit efficiency
5._____Provide benefit in accuracy.
6._____Should be used at any phase of the acquisition cycle.

SECTION 4
The statements below refer to the main challenges or barriers to parametric estimating. Identify the TOP 5 with 1 being the BIGGEST challenge or barrier, 2 the next biggest, etc.

___database
___training
___accuracy
___risk assessment
___TINA
___current business environment
___other (please identify)

_____

_____lack of Government support
_____lack of Industry support
_____utility/usefulness
_____model development
_____difficulty of use
_____acquisition rules and regulations (please identify)

_____

Section 5 Demographic Information
This section of the survey contains several items dealing with personal characteristics. This information will be used to obtain a picture about experience and differences in government versus contractor perspectives.

1. How much experience do you have: _____years
2. What best describes the work that you do (i.e. price analyst, estimator, contracts etc)?_____
3. What organization do you work for (i.e. industry, consultant, DCAA, DCMC, Govt)? _____
4. How many estimates have you prepared or analyzed using parametric models? _____
5. How many proposals (contract prices) have you prepared or analyzed using parametric models? _____

Thank you for taking the time to complete this questionnaire.
Any comments you would like to make about the questionnaire or implementing parametrics are welcome.

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Vita

Ms. Patricia Blakely was born on 9 August 1958 in Columbus, Georgia. She graduated from Wayne High School in Huber Heights, Ohio in 1976 and attended Miami University in Oxford, Ohio. In 1980, she graduated with a Bachelor of Science in Business Administration, majoring in Finance. She began her contracting career as a procurement analyst at the Defense Electronic Supply Center in Kettering, Ohio. In 1984, she transferred to the Aeronautical Systems Center, WPAFB, Ohio where she worked as a contract negotiator in the Reconnaissance Strike/Electronic Warfare Systems Program Office (SPO), Strategic Systems SPO, Propulsion SPO, Simulator SPO, F-16 SPO, Specialized Contracting Office, and the Resource Management Office. In 1989, she received her contracting officer warrant. She was selected to attend long-term full-time training at the Air Force Institute of Technology and, in May 1997, entered the Graduate School of Logistics and Acquisition Management in Contract Management. Ms. Blakely is married to Kelly Blakely and has two children: a daughter Jessica and a son Casey.

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An initiative to expand the use of parametric estimating in government contracting has enjoyed only marginal success. Some reasons for the slower pace of implementation are the lack of availability of historical data, training, acquisition rules, utility, and accuracy concerns. Those associated with the Parametric Cost Estimating Initiative (PCEI) have a higher perception of parametric utility and accuracy than those not associated with the initiative. The PCEI advocates using parametric techniques in any situation, not just the concept/development phases advocated by most literature.

Parametric estimating is a catch-all term for several different types of statistically based methodologies, ranging from simple CERs to complex models. Each type has different implementation requirements. Using the single term parametrics can be very deceiving, making it difficult for management to allocate resources necessary for implemetation.

PCEI and non-PCEI acquisition groups have similar perceptions of accuracy and utility for CERs, but different perceptions for more complex parametric models. The PCEI has been successful expanding the use of parametrics, though not significantly enough to be persuasive. Most of the PCEI successes have been related to CERs, not complex models. Advances in complex model use has occurred with contractors who routinely develop state of the art hardware.

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AFIT RESEARCH ASSESSMENT

The purpose of this questionnaire is to determine the potential for current and future applications of AFIT thesis research. **Please return completed questionnaire** to: AIR FORCE INSTITUTE OF TECHNOLOGY/LAC, 2950 P STREET, WRIGHT-PATTERSON AFB OH 45433-7765. Your response is **important.** Thank you.

1. Did this research contribute to a current research project?   a. Yes   b. No

2. Do you believe this research topic is significant enough that it would have been researched (or contracted) by your organization or another agency if AFIT had not researched it?

                                                a. Yes   b. No

3. **Please estimate** what this research would have cost in terms of manpower and dollars if it had been accomplished under contract or if it had been done in-house.

         Man Years_____ $_____

4. Whether or not you were able to establish an equivalent value for this research (in Question 3), what is your estimate of its significance?

     a. Highly   b. Significant   c. Slightly   d. Of No
        Significant   Significant   Significance

5. Comments (Please feel free to use a separate sheet for more detailed answers and include it with this form):

_____   _____
Name and Grade   Organization

_____   _____
Position or Title   Address